Citations Utilized in Post-Construction Rulemaking Project Deliverables as of June 17, 2010

Abt Associates, I. (2006). Benefits of Water Quality Monitoring at U.S. Coastal Beaches.

Acharya, G. and L. L. Bennett (2001). "Valuing Open Space and Land-Use Patterns in Urban Watersheds." The Journal of Real Estate Finance and Economics **22**(2-3): 221-237.

> This article presents the results of a hedonic property value analysis for an urban watershed in New Haven County, Connecticut. We use spatially referenced housing and land-use data to capture the effect of environmental variables around the house location. We calculate and incorporate data on open space, land-use diversity, and other environmental variables to capture spatial variation in environmental quality around each house location. We are ultimately interested in determining whether variables that are reflective of spatial diversity do a better job of describing human preferences for housing choice than broad categories of rural versus urban areas. Using a rich data set of over 4,000 houses, we study these effects within a watershed that includes areas of high environmental quality and low environmental quality as well as varying patterns of socioeconomic conditions. Our results suggest that, in addition to structural characteristics, variables describing neighborhood socioeconomic characteristics and variables describing land use and environmental quality are influential in determining human values. We also find that the scale at which we measure these spatially defined environmental variables is important.

Ackerman, D. and E. D. Stein (2008). "Estimating the variability and confidence of land use and imperviousness relationships at a regional scale." Journal of the American Water Resources Association **44**: 996-1008.

Allan, J. D. (2004). "Landscapes and riverscapes: The influence of land use on stream ecosystems." Annual Review of Ecology Evolution and Systematics **35**: 257-284.

Allen, P. M., J. G. Arnold, et al. (2008). "Prediction of channel degradation rates in urbanizing watersheds." Hydrological Sciences Journal-Journal Des Sciences Hydrologiques **53**: 1013-1029.

Allison, R. F., F. H. S. Chiew, et al. (1997). Stormwater Gross Pollutants, Collaborative Research Centre for Catchment Hydrology.

Arnold, C. L., P. J. Boison, et al. (1982). "Sawmill Brook: An Example of Rapid Geomorphic Change Related to Urbanization." The Journal of Geology **90**(2): 155-166.

> The watershed of Sawmill Brook is undergoing urbanization that has increased the frequency of bankfull discharge. The increased runoff is causing extensive

bank erosion in the main channel that has increased the size of the bed material and the rate of bedload discharge. The increased frequency of moderate floods, the channel widening, and the change in the sediment transport regime is causing a change from a meandering to a braided channel pattern. With continued urbanization of the basin the present disequilibrium of the channel will be enhanced resulting in an unstable channel pattern for Sawmill Brook.

Babbitt, K. J. (2005). "The relative importance of wetland size and hydroperiod for amphibians in southern New Hampshire, USA." Wetlands Ecology and Management **13**(3): 269-279.

In the United States, the regulatory approach to wetland protection has a traditional focus on size as a primary criterion, with large wetlands gaining significantly more protection. Small, isolated wetlands have received less protection; however, these wetlands play a significant role in the maintenance of biodiversity of many taxonomic groups, including amphibians. An important question for directing conservation and management efforts for amphibians is whether size is a useful criterion for regulatory decisions. Because hydroperiod has an important influence on amphibian composition in wetlands, I conducted a study to examine the relative influence of wetland size and hydroperiod on amphibian occurrence. I sampled 103 wetlands in southern New Hampshire in 1998 and 1999 using dipnet sampling to document the presence of larval amphibians. Wetlands were placed into one of three hydroperiod categories; short (<4 months), intermediate (4–11 months), or long (permanent) based on field observations of drying pattern. Wetland size was determined from digitized national wetland inventory (NWI) maps (most wetlands) or measured in the field. I examined patterns of amphibian species richness and individual species occurrence using generalized linear models. Wetland size ranged from 0.01 to 3.27 ha. Overall, species richness was significantly influenced by hydroperiod ($\chi 2 = 18.6$, $p < 0.001$), but not size ($\chi 2 = 1.4$, $p = 0.24$). Examination within hydroperiod categories revealed several significant relationships with wetland size. Species richness was related to wetland size in wetlands with short and intermediate hydroperiods, but not wetlands with long hydroperiods. Wetland size does not appear to be a useful sole criterion for determining wetland functional value for amphibians; assessments of functions of seasonally inundated wetlands for amphibians would benefit from examination of hydroperiod.

Bannerman, R. T., D. W. Owens, et al. (1993). "Sources of Pollutants in Wisconsin Stormwater." Water Science and Technology **28**: 241-259.

Battin, J. (2004). "When good animals love bad habitats: Ecological traps and the conservation of animal populations." Conservation Biology **18**(6): 1482-1491.

The concept of the ecological trap, a low-quality habitat that animals prefer over other available habitats of higher quality, has appeared in the ecological literature irregularly for over 30 years, but the topic has received relatively little attention, and evidence for traps remains largely anecdotal. Recently, however, the

ecological trap concept has been the subject of a flurry of theoretical activity that is likely to raise its profile substantially, particularly in conservation biology. Ecological trap theory suggests that, under most circumstances, the presence of a trap in a landscape will drive a local population to extinction. A number of empirical studies, almost all of birds, suggest the existence of traps and demonstrate the difficulties of recognizing them in the field. Evidence for ecological traps has primarily been found in habitats modified by human activities, either directly (e.g., through the mowing of grassland birds' nests) or indirectly (e.g., via human-mediated invasion of exotic species), but some studies suggest that traps may occur even in relatively pristine areas. Taken together, these theoretical and empirical results suggest that traps may be relatively common in rapidly changing landscapes. It is therefore important for conservation biologists to be able to identify traps and differentiate them from sinks. Commonly employed approaches for population modeling, which tend to assume a source-sink framework and do not consider habitat selection explicitly, may introduce faulty assumptions that mask the effects of ecological traps and lead to overly optimistic predictions about population persistence. Given the potentially dire consequences of ecological traps and the accumulating evidence for their existence, greater attention from the community of conservation biologists is warranted. In particular, it is important for conservation biologists and managers to incorporate into conservation planning an explicit understanding of the relationship between habitat selection and habitat quality.

Bay, S., B. H. Jones, et al. (2003). "Water quality impacts of stormwater discharges to Santa Monica Bay." Marine Environmental Research **56**: 205-223.

Beasley, G. and P. Kneale (2002). "Reviewing the impact of metals and PAHs on macro invertebrates in urban watercourses." Progress in Physical Geography **26**: 236-270.

Bedan, E. S. and J. C. Clausen (2009). "Stormwater Runoff Quality and Quantity From Traditional and Low Impact Development Watersheds(1)." Journal of the American Water Resources Association **45**: 998-1008.

Bergstrom, J. C., K. J. Boyle, et al. (1996). "Assessing the economic benefits of ground water for environmental policy decisions." Journal of the American Water Resources Association **32**(2): 279-291.

The full range of environmental and economic services of ground water need to be accounted for in policy decisions. Non-recognition of these services imputes a lower value for the ground water resource in establishing policies. We describe a conceptual framework for identifying and measuring the economic value of groundwater. The valuation framework links changes in physical characteristics of ground water to services provided by ground water and the economic effects of changes in ground water services. In addition to the framework, we develop a general protocol to follow for assessing the benefits of ground water policies. Application of the protocol will aid in establishing structure and consistency

across policy assessments and improve the accuracy and completeness of benefit estimates, avoid double-counting problems, and eliminate duplication of ground water valuation efforts.

Berke, P. R., J. Macdonald, et al. (2003). "Greening Development to Protect Watersheds: Does New Urbanism Make a Difference?" Journal of the American Planning Association **69**(4): 397-397.

New urbanism has been touted as a more environmentally sustainable form of development than conventional low-density sprawl. To test this assertion, this study comparatively evaluates how well 50 matched pairs of new urban and conventional developments in the United States integrate watershed protection techniques. Findings indicate that new urban development practices offer a greener and more compact alternative to sprawl in greenfields on the suburban fringe, as they are more likely to protect and restore sensitive areas, reduce impervious cover, and incorporate best management practices. New urban developments in infill sites are more likely to incorporate impervious surface reduction techniques and restore degraded stream environments, but have equivalent levels of sensitive area protection and use of best management practices. Recommendations offer ways in which watershed protection techniques can be used to implement more environmentally sustainable development.

Bernhardt, E. S. and M. A. Palmer (2007). "Restoring streams in an urbanizing world." Freshwater Biology **52**(4): 738-7851.

1. The world's population is increasingly urban, and streams and rivers, as the low lying points of the landscape, are especially sensitive to and profoundly impacted by the changes associated with urbanization and suburbanization of catchments. 2. River restoration is an increasingly popular management strategy for improving the physical and ecological conditions of degraded urban streams. In urban catchments, management activities as diverse as stormwater management, bank stabilisation, channel reconfiguration and riparian replanting may be described as river restoration projects. 3. Restoration in urban streams is both more expensive and more difficult than restoration in less densely populated catchments. High property values and finely subdivided land and dense human infrastructure (e.g. roads, sewer lines) limit the spatial extent of urban river restoration options, while stormwaters and the associated sediment and pollutant loads may limit the potential for restoration projects to reverse degradation. 4. To be effective, urban stream restoration efforts must be integrated within broader catchment management strategies. A key scientific and management challenge is to establish criteria for determining when the design options for urban river restoration are so constrained that a return towards reference or pre-urbanization conditions is not realistic or feasible and when river restoration presents a viable and effective strategy for improving the ecological condition of these degraded ecosystems.

Birdsey, R. A. (1992). Carbon Storage and Accumulation in United States Forest Ecosystems. Northeastern Forest Experiment Station, Radnor, PA, United States Department of Agriculture, Forest Service**:** 51-51.

> Historically, assessments of the forest resource situation have focused on timber supply, and the data used to support the assessments came from traditional forest inventories designed to provide reliable estimates of timber volume, growth, removals, and mortality (U.S. Department of Agriculture, Forest Service 1982). The most recent assessment included data and analysis of forest resources other than timber, including wildlife, range, water, recreation, and other resources associated with the Nation's forest lands (U.S. Department of Agriculture, Forest Service 1989). Future forest resource assessments will include expanded analyses of environmental issues such as the effects of acid deposition on forest health, the prospective effects of global warming on forests, and the impacts of prospective strategies to mitigate or adapt to changing environmental conditions. A key issue analyzed in the 1989 Resources Planning Act (RPA) Assessment is the impact of climate change on America's forests (Joyce and others 1990). Another issue undergoing intense analysis at this time but not included in the 1989 RPA Assessment is the evaluation of forestry opportunities for mitigating the effects of global warming. Analysis of forestry opportunities requires knowledge of carbon storage and accumulation in forest ecosystems. It is the purpose of this publication to provide estimates of carbon storage and accumulation for U.S. forests. Because it takes years to design and conduct detailed inventories of U.S. forest lands, the only way to satisfy current, expanding information needs is to integrate the best available data from the national inventory sample with data from special studies of selected forest ecosystems

Birx-Raybuck, D. A., S. J. Price, et al. (2010). "Pond age and riparian zone proximity influence anuran occupancy of urban retention ponds." Urban Ecosystems **13(**2): 181-190.

> Urbanization is widespread throughout the United States and negatively affects many wildlife populations. However, certain urban features, such as retention ponds, may provide habitat for some species, such as amphibians. This study examines the influence of riparian zone proximity and pond age on retention pond occupancy by anurans. We identified and estimated the age of 25 retention ponds near Charlotte, North Carolina, USA and used a geographic information system to determine the distance to the nearest riparian zone. Occupancy modeling indicated that anuran presence decreased with increasing distance to riparian zone. Pond age also appeared to be an important factor, but the effect varied among species. Although the results of this study demonstrate the potential value of retention ponds to anurans, it is important to be conservative in estimating the ability of these ponds to sustain amphibian populations in urbanized regions.

Bishop, B. E., B. A. Savitzky, et al. (2010). "Lead bioaccumulation in emydid turtles of an urban lake and its relationship to shell disease." Ecotoxicology and Environmental Safety **In Press, Corrected Proof**.

Bjorklund, K., A. P. Cousins, et al. (2009). "Phthalates and nonylphenols in urban runoff: Occurrence, distribution and area emission factors." Science of The Total Environment **407**: 4665-4672.

Bledsoe, B. P. and C. C. Watson (2001). "Effects of urbanization on channel instability." Journal of the American Water Resources Association **37**: 255-270.

Booth, D. B., D. Hartley, et al. (2002). "Forest cover, impervious-surface area, and the mitigation of stormwater impacts." Journal of the American Water Resources Association **38**: 835-845.

Booth, D. B. and C. R. Jackson (1997). "Urbanization of aquatic systems: Degradation thresholds, stormwater detection, and the limits of mitigation." Journal of the American Water Resources Association **33**: 1077-1090.

Bowen, J. L. and I. Valiela (2001). "The ecological effects of urbanization of coastal watersheds: historical increases in nitrogen loads and eutrophication of Waquoit Bay estuaries." Canadian Journal of Fisheries and Aquatic Sciences **58**: 1489-1500.

Brabec, E., S. Schulte, et al. (2002). "Impervious surfaces and water quality: A review of current literature and its implications for watershed planning." Journal of Planning Literature **16**: 499-514.

Brabec, E. A. (2009). "Imperviousness and Land-Use Policy: Toward an Effective Approach to Watershed Planning." Journal of Hydrologic Engineering **14**: 425-433.

Brack, C. L. (2002). "Pollution mitigation and carbon sequestration by an urban forest." Environmental Pollution **116**(Supplement 1): S195-S200-S195-S200.

> At the beginning of the 1900s, the Canberra plain was largely treeless. Graziers had carried out extensive clearing of the original trees since the 1820s leaving only scattered remnants and some plantings near homesteads. With the selection of Canberra as the site for the new capital of Australia, extensive tree plantings began in 1911. These trees have delivered a number of benefits, including aesthetic values and the amelioration of climatic extremes. Recently, however, it was considered that the benefits might extend to pollution mitigation and the sequestration of carbon. This paper outlines a case study of the value of the Canberra urban forest with particular reference to pollution mitigation. This study uses a tree inventory, modelling and decision support system developed to collect and use data about trees for tree asset management. The decision support system (DISMUT) was developed to assist in the management of about 400,000 trees planted in Canberra. The size of trees during the 5-year Kyoto Commitment Period was estimated using DISMUT and multiplied by estimates of value per square meter of canopy derived from available literature. The planted trees are

estimated to have a combined energy reduction, pollution mitigation and carbon sequestration value of US$20–67 million during the period 2008–2012.

Braden, J. B. and D. M. Johnston "Downstream Economic Benefits from Storm-Water Management." Journal of Water Resources Planning and Management-Asce **130**(6): 498-505.

Using benefits transfer methods, this paper assesses the downstream economic consequences of development designs that promote greater on-site water retention. It concludes that on-site retention provides many services that are conceptually distinct but empirically intertwined. Flood mitigation and water quality protection are the most important of these services. For residential properties, the economic value of those services is on the order of 0–5% of market value depending on the difference that retention makes to downstream flood exposure. For water quality improvements, the increases range up to 15% of market value for waterside residences where clarity of the water quality is greatly improved. The increases are much less for improvements that are less visible, properties that are not developed, and properties not adjacent to the watercourse. Our best estimate of total benefits to property owners is 2–5% of property value on average for all properties in the flood plain. The public sector realizes additional benefits through smaller bridges, culverts, and other drainage infrastructure and through increased aquifer recharge. Cities and industries may avoid costly upgrades to waste water treatment facilities if low flows increase. It is difficult to generalize about the economic value of the latter effects.

Brand, A. B. and J. W. Snodgrass (2009). "Value of Artificial Habitats for Amphibian Reproduction in Altered Landscapes." Conservation Biology **24**: 295-301.

Installation and maintenance of stormwater ponds to detain and treat runoff from impervious surfaces is a common method of stormwater control in developed areas. That these ponds capture pollutants, however, is of concern for wildlife species that use the ponds, particularly pond-breeding amphibians. To assess the relative contribution of stormwater ponds to the persistence of amphibian populations in suburban landscapes, we compared amphibian use of stormwater ponds and other available wetlands in suburban and forested watersheds. We surveyed three suburban and three primarily forested first-order watersheds to identify all potential wetlands that might serve as breeding sites for pond-breeding amphibians. We performed call, egg-mass, and larval surveys to measure breeding effort at each wetland in spring and summer 2007 and 2008. In suburban watersheds most (89%) of the wetlands that had breeding activity were either stormwater ponds or otherwise artificial. This pattern was also evident in the forested watersheds, where amphibians were primarily found breeding in wetlands created by past human activity. Late-stage larvae were found only in anthropogenic wetlands in all study areas because the remaining natural wetlands did not hold water long enough for larvae to complete development. Our results suggest that in urban and suburban landscapes with naturally low densities of wetlands, wetlands created by current or historic land uses may be as important to

amphibian conservation as natural wetlands or pools and that management strategies directed at urban and suburban landscapes should recognize and incorporate human-created wetlands.

Brander, K. E., K. E. Owen, et al. (2007). "MODELED IMPACTS OF DEVELOPMENT TYPE ON RUNOFF VOLUME AND INFILTRATION PERFORMANCE1." JAWRA Journal of the American Water Resources Association **40**(4): 961-969.

ABSTRACT: Development type has emerged as an important focal point for addressing a wide range of social, cultural, and environmental concerns related to urban growth. Low impact development techniques that rely heavily on infiltration practices are increasingly being used to manage storm water. In this study, four development types (conventional curvilinear, urban cluster, coving, and new urbanism) were modeled both with and without infiltration practices to determine their relative effects on urban runoff. Modeling was performed with a modified version of the Natural Resources Conservation Service (NRCS) runoff method that enables evaluation of infiltration practices. Model results indicate that urban cluster developments produce the smallest volume of runoff due to the large portion of land kept in a natural condition. Infiltration practices are most effective for small storms and in developments with Hydrologic Group A soils. Significant reductions in runoff can be achieved in all four development types if infiltration practices treat many impervious surfaces. As more infiltration practices are implemented, the differences in runoff among development types diminish. With a strategic combination of site layout and infiltration design, any development type can reduce hydrologic impacts, allowing developers to consider other factors, such as convenience, marketability, community needs, and aesthetics.

Bressler, D. W., M. J. Paul, et al. (2009). "ASSESSMENT TOOLS FOR URBAN CATCHMENTS: DEVELOPING STRESSOR GRADIENTS." Journal of the American Water Resources Association **45**: 291-305.

Bryant, W. L. and S. L. Goodbred (2009). "The response of hydrophobic organics and potential toxicity in streams to urbanization of watersheds in six metropolitan areas of the United States." Environmental Monitoring and Assessment **157**: 419-447.

Buckingham, S. E. and J. W. Whitney (2007). "GIS Methodology for Quantifying Channel Change in Las Vegas, Nevada." Journal of the American Water Resources Association **43**(4): 888-898.

Burcher, C. L., H. M. Valett, et al. (2007). "The land-cover cascade: Relationships coupling land and water." Ecology **88**: 228-242.

Burns, D., T. Vitvar, et al. (2005). "Effects of suburban development on runoff generation in the Croton River basin, New York, USA." Journal of Hydrology **311**: 266-281.

California Regional Water Quality Control, B. (2007). Trash Total Maximum Daily Loads for the Los Angeles River Watershed.

Campbell, K. R. (1994). "Concentrations of heavy metals associated with urban runoff in fish living in stormwater treatment ponds." Archives of Environmental Contamination and Toxicology **27**(3): 352-356.

Carle, M. V., P. N. Halpin, et al. (2005). "Patterns of watershed urbanization and impacts on water quality." Journal of the American Water Resources Association **41**: 693-708.

Carriquiry, J. D., A. Sánchez, et al. (2001). "Sedimentation in the northern Gulf of California after cessation of the Colorado River discharge." Sedimentary Geology **144**(1-2): 37-62.

> The almost total elimination of sediment supply from the Colorado River has produced a condition of sediment starvation in the entire northern Gulf of California (NGC). Textural and mineralogical analyses of 114 surface sediment samples collected in the area show that this situation has promoted alternate sediment sources to become more important in supplying and controlling the compositional characteristics of the sediments in the region. By applying multivariate data analyses using Q/F ratios as well as heavy mineral and clay mineral content of samples, four sedimentary provinces are identified: Colorado River Delta Province (CRDP), Concepción River Province (CcRP), Transitional Province (TP) and Baja-Sonora Province (BSP). The CRDP dominates the regional distribution of sediments, being mainly confined to the western side of the NGC. The sediment source for this province is the deltaic structure of the Colorado River. Sediment recycling through resuspension and reworking of the Colorado delta and the shallow shelf of the Upper Gulf of California (UGC) is an important agent for supplying sediments to the NGC. The CcRP reflects the mineralogical association of Concepción River, while the TP contains a mineral association that is similar to CRDP and CcRP, but with intermediate values to these provinces. This situation suggests that TP is a mixing zone between these two neighboring provinces. The higher abundance of zircon and garnet in TP also suggests a clear contribution of sediment sources from the Sonora desert in NW Mexico. Clay mineral composition of these sediments indicates a greater abundance of smectite and chlorite relative to previous studies, being mainly derived from eolian dust carried from the desert region of NW-Mexico and SW-USA. Although eolian supply of fine-grained sediments is important in the NGC, Colorado River delta sediments are still the largest single source of sediments to the region. Eolian supply of fine-grained sediments is, however, more dominant in the southern half, and along the eastern margin of the NGC. The dispersion of sediments in the NGC is consistently cross-basinal with a series of transport cells that follow a cyclonic circulation. Four depocenters were identified, located all on the western side of the NGC, and mainly associated to the deep basins. The major effect that damming of the Colorado River has had on the sedimentology of the area is that sediment dispersion is now cross-basinal instead of long-basinal. This

situation indicates that sediment dispersion at present is mainly controlled by oceanic forcing instead of fluvial processes, as it was in the past.

Carter, T. and C. R. Jackson (2007). "Vegetated roofs for stormwater management at multiple spatial scales." Landscape and Urban Planning **80**(1-2): 84-94.

Stormwater runoff from impervious surfaces and other urban land cover is particularly detrimental to receiving water bodies in urban centers. A variety of management practices exist to combat the environmental degradation associated with the altered hydrology in urban areas. Vegetated, or green, roofs are emerging as one of these stormwater management tools in the United States. Investigations have primarily been focused on roof-scale processes such as individual roof stormwater retention, plant growth, or growing media composition. Few studies have examined the impact that widespread green roof application could have on the hydrology of a real-world watershed. Using local green roof stormwater retention data, this study modeled hydrologic effects of green roofing scenarios in an urban watershed at a variety of spatial scales. A detailed spatial analysis demonstrated areas of the watershed where green roofs would significantly reduce the total impervious area and provide additional stormwater storage. Hydrologic modeling demonstrated that widespread green roof implementation can significantly reduce peak runoff rates, particularly for small storm events. This analysis recommends the use of vegetative roofs as an abstractive stormwater best management practice in urban watersheds to replicate the interception and evapotranspiration aspects of the water cycle found in less disturbed environments.

Casey, R. E., A. N. Shaw, et al. (2005). "Multimedia Evaluation of Trace Metal Distribution Within Stormwater Retention Ponds in Suburban Maryland, USA." Bulletin of Environmental Contamination and Toxicology **74**(2): 273-280.

Center for Watershed, P. (2003). "Impacts of Impervious Cover on Aquatic Systems." 158-158.

Center for Watershed, P. (2006). Direct and Indirect Impacts of Urbanization on Wetland Quality**:** 93-93.

Chang, H. J. (2007). "Comparative streamflow characteristics in urbanizing basins in the Portland Metropolitan Area, Oregon, USA." Hydrological Processes **21**: 211-222.

Changnon, S. A. and N. E. Westcott (2002). "HEAVY RAINSTORMS IN CHICAGO: INCREASING FREQUENCY, ALTERED IMPACTS, AND FUTURE IMPLICATIONS." Journal of the American Water Resources Association **38**(5): 1467-1475.

Operations of a dense raingage network in the Chicago area since 1989 provided data to assess the temporal and spatial distributions of heavy rainstorms. The 12-year average was 4.4 storms per year, 40 percent more than in the 1948 to 1980

period, reflecting an ongoing Midwestern increase in heavy rains. The total rainfall from the 53 heavy rainstorms maximized over the city, reflecting previous observations that the influence of the city and Lake Michigan on the atmosphere causes an increase in heavy rains. Impacts from the record high number of eight storms in 2001 revealed that efforts to control flooding including the Deep Tunnel system, had reduced street and basement flooding in the moderate intensity storms, but the two most intense storms, each with 100-year rainfall values, led to excessive flooding and a need to release flood waters into Lake Michigan. Results suggest continuing increases in the number of heavy rainstorms in future years, which has major implications for water managers in Chicago and elsewhere.

Chen, Y. S., L. S. Lin, et al. (2007). "Nonpoint source pollution." Water Environment Research **79**: 2032-2048.

Chen, Y. S., R. C. Viadero, et al. (2009). "Effects of Highway Construction on Stream Water Quality and Macroinvertebrate Condition in a Mid-Atlantic Highlands Watershed, USA." Journal Of Environmental Quality **38**: 1672-1682.

Cheng, M. S., L. S. Coffman, et al. (2004). Comparison of Hydrological Responses from Low Impact Development with Conventional Development.

In November of 2000, the Department of Environmental Resources (DER) of Prince George's County, Maryland initiated a field-monitoring program to compare the stormwater hydrologic and water quality responses between a Low Impact Development (LID) design and the conventional development design at Somerset Heights Subdivision. In the Subdivision, two small watersheds are located side-by side: one was developed using a few LID concepts (grassed swales, bioretention areas, etc) with drainage area of 11.84 acres and another was developed entirely using a conventional stormwater conveyance system (a curb, gutter and pipe stormwater conveyance system) with a drainage area of 8.43 acres. The monitoring program, including one rain gage, two stream gages and two water quality automatic samplers, is capable of collecting continuous data in a 2-minute time interval. So far, more than two years of continuous flow and water quality data have been collected at both sites. The program is now moving into the third year of operation. This paper presents a data summary and analysis for the first two years of the monitoring program.

Cianfrani, C. M., W. C. Hession, et al. (2006). "Watershed imperviousness impacts on stream channel condition in southeastern Pennsylvania." Journal of the American Water Resources Association **42**: 941-956.

Clark, E., J. A. Haverkamp, et al. (1985). Eroding Soils: The Off-Farm Impacts**:** 252-252.

Clark, J. J. and P. R. Wilcock (2000). "Effects of land-use change on channel morphology in northeastern Puerto Rico." Geological Society of America Bulletin **112**(12): 1763-1777.

Between 1830 and 1950 much of northeastern Puerto Rico was cleared for agriculture. Runoff increased by [~]50% and sediment supply to the river channels increased by more than an order of magnitude. Much of the land clearance extended to steep valley slopes, resulting in widespread gullying and landslides and a large load of coarse sediments delivered to the stream channels. A shift from agriculture to industrial and residential land uses over the past 50 yr has maintained the elevated runoff while sediment supply has decreased, allowing the rivers to begin removing coarse sediment stored within their channels. The size, abundance, and stratigraphic elevation of in-channel gravel bar deposits increases, channel depth decreases, and the frequency of overbank flooding increases downstream along these channels. This is presumed to be a transient state and continued transport will lead to degradation of the bed in downstream sections as the channel adjusts to the modern supply of water and sediment. A downstream decrease in channel size is contrary to the expected geometry of self-adjusted channels, but is consistent with the presence of partially evacuated sediment remaining from the earlier agricultural period. Reverse (downstream decreasing) channel morphology is not often cited in the literature, although consistent observations are available from areas with similar land-use history. Identification of reverse channel morphology along individual watercourses may be obscured in multiwatershed compilations in which other factors produce a consistent, but scattered downstream trend. Identification of reverse channel morphology along individual streams in areas with similar land-use history would be useful for identifying channel disequilibrium and anticipating future channel adjustments.

Coles, J. F., T. F. Cuffney, et al. (2010). "Judging a Brook by Its Cover: The Relation between Ecological Condition of a Stream and Urban Land Cover in New England." Northeastern Naturalist **17**(1): 29-48.

The US Geological Survey conducted an urban land-use study in the New England Coastal Basins (NECB) area during 2001 to determine how urbanization relates to changes in the ecological condition of streams. Thirty sites were selected that differed in their level of watershed development (low to high). An urban intensity value was calculated for each site from 24 landscape variables. Together, these 30 values reppresented a gradient of urban intensity. Among various biological, chemical, and physical factors surveyed at each site, benthic invertebrate assemblages were sampled from stream riffles and also from multiple habitats along the length of the sampling reach. We use some of the NECB data to derive a four-variable urbanintensity index (NECB-UII), where each variable represents a distinct component of urbanization: increasing human presence, expanding infrastructure, landscape development, and riparian vegetation loss. Using the NECB-UII as a characterization of urbanization, we describe how landscape fragmentation occurs with urbanization and how changes in the invertebrate assemblages, represented by metrics of ecological condition, are related to urbanization. Metrics with a strong linear response included EPT taxa richness, percentage richness of non-insect taxa, and pollution-tolerance values.

Additionally, we describe how these relations can help in estimating the expected condition of a stream for its level of urbanization, thereby establishing a baseline for evaluating possible affects from specific point-source stressors.

Colosimo, M. F. and P. R. Wilcock (2007). "Alluvial sedimentation and erosion in an urbanizing watershed, Gwynns Falls, Maryland." Journal of the American Water Resources Association **43**: 499-521.

Cook, E. A. (2007). "Green Site Design: Strategies for Storm Water Management." Journal of Green Building **2**(4): 46-56.

Cunningham, M. A., C. M. O'Reilly, et al. (2009). "THE SUBURBAN STREAM SYNDROME: EVALUATING LAND USE AND STREAM IMPAIRMENTS IN THE SUBURBS." Physical Geography **30**: 269-284.

Cuo, L., D. P. Lettenmaier, et al. (2009). "Effects of a century of land cover and climate change on the hydrology of the Puget Sound basin." Hydrological Processes **23**: 907-933.

Davis, A. P., M. Shokouhian, et al. (2001). "Laboratory study of biological retention for urban stormwater management." Water Environment Research **73**: 5-14.

de Groot, R. S., M. A. Wilson, et al. (2002). "A typology for the classification, description and valuation of ecosystem functions, goods and services." Ecological Economics **41**(3): 393-408.

An increasing amount of information is being collected on the ecological and socio-economic value of goods and services provided by natural and semi-natural ecosystems. However, much of this information appears scattered throughout a disciplinary academic literature, unpublished government agency reports, and across the World Wide Web. In addition, data on ecosystem goods and services often appears at incompatible scales of analysis and is classified differently by different authors. In order to make comparative ecological economic analysis possible, a standardized framework for the comprehensive assessment of ecosystem functions, goods and services is needed. In response to this challenge, this paper presents a conceptual framework and typology for describing, classifying and valuing ecosystem functions, goods and services in a clear and consistent manner. In the following analysis, a classification is given for the fullest possible range of 23 ecosystem functions that provide a much larger number of goods and services. In the second part of the paper, a checklist and matrix is provided, linking these ecosystem functions to the main ecological, socio–cultural and economic valuation methods.

Despotovic, J., J. Plavsic, et al. (2005). "Inefficiency of storm water inlets as a source of urban floods." Water Science and Technology: A Journal of the International Association on Water Pollution Research **51**(2): 139-145.

The paper attempts to explain sources of surplus storm water runoff in urban areas, particularly in relation with functioning of inlets. Inlet capacity (quantity of captured water) and inlet efficiency (portion of the approaching flow rate) have been defined and their relationship with relevant parameters (approaching flow, longitudinal and lateral street slopes) was established through laboratory measurements. Effects of clogging of inlets on inlet capacity were also investigated in laboratory conditions. As a consequence of decreased inlet efficiency, there is a portion of approaching flow that is not captured by the inlet (pass-over flow). If the pass-over flow is considered along a street having numerous inlets, it is easy to estimate the quantity of flow that would accumulate on the pavement. Inlet inefficiency can be significant when overestimation of inlet capacity results in increased distance between consecutive inlets, and when clogging of grates or inadequate placing of inlets causes significant decrease in inlet capacity.

Deutsch, B., H. Whitlow, et al. (2005). RE-GREENING WASHINGTON, DC: A Green Roof Vision Based on Quantifying Storm Water and Air Quality Benefits, Casey Trees Endowment Fund, Limno-Tech, Inc.**:** 15-15.

This paper presents a quantitative assessment of the storm water and air quality benefits provided by green roofs at different coverage scenarios in Washington, DC. Quantifying these benefits allows the contribution of green roofs to be included in developing solutions to air and water quality problems in the District of Columbia, improving public health, optimizing capital investment in municipal infrastructure, and guiding future growth as the city redevelops.

DiBari, J. N. (2007). "Evaluation of five landscape-level metrics for measuring the effects of urbanization on landscape structure: the case of Tucson, Arizona, USA." Landscape and Urban Planning **79**: 308-313.

Dickman, C. R. "Habitat Fragmentation and Vertebrate Species Richness in an Urban Environment." Journal of Applied Ecology **24**(2): 337-351.

Species of terrestrial mammals, reptiles and amphibians were surveyed in patches of semi-natural and disturbed vegetation within the City of Oxford. The patches were delimited by roads, walls or other artificial barriers, and ranged from 0.16 ha to 20 ha. A total of twenty species of mammals was recorded, two to seventeen species occurring per patch. Mammalian species richness (the number of species) within patches decreased with increasing percentage of barren ground per patch, with proximity to buildings, and with patchiness in the total vegetation cover, but increased with increasing density of vegetation in the layer 21–50 cm above ground. Five species of amphibians and four species of reptiles were recorded, zero to seven species occurring per patch. The richness of these taxa within patches increased with patch area, but declined away from sources of permanent water. More species of mammals, amphibians and reptiles were retained in two small habitat patches than in one large patch equal to their combined area. For mammals, excluding large species such as deer, species richness in the urban

environment can be preserved by maintaining a system of small (≥0.65 ha) patches of undisturbed woodland throughout the city area. The richness of reptiles and amphibians can probably be preserved by maintaining patches of ≥0.55 ha that provide permanent water.

Dietz, M. (2007). "Low Impact Development Practices: A Review of Current Research and Recommendations for Future Directions." Water, Air, & Soil Pollution **186**(1): 351-363.

Abstract The low impact development (LID) approach has been recommended as an alternative to traditional stormwater design. Research on individual LID practices such as bioretention, pervious pavements, and grassed swales has increased in recent years. Bioretention cells have been effective in retaining large volumes of runoff and pollutants on site, and consistently reduced concentrations of certain pollutants such as metals. However, retention of certain pollutants such as nitrate–nitrogen and phosphorus has been problematic. Porous pavements have been extremely effective in infiltrating stormwater runoff. Concerns have been raised about groundwater contamination, but research has shown that this is not a problem in most settings. Green roofs have been found to retain a large percentage of rainfall (63% on average) in a variety of climates. A common thread across bioretention, green roofs and grassed swales was found: the export of phosphorus. The issue appears to be linked to high phosphorus levels in the soil media, or possibly to fertilization of turf or planted areas. Solutions to this problem have been recommended. Contrary to popular belief, research has shown that bioretention and pervious pavements continue to infiltrate even with frost in the ground. Although issues have been identified with retention of certain pollutants, the LID approach has been found to result in increased retention of stormwater and pollutants on site, mimicking pre-development hydrologic function. Future research needs have also been identified.

Dietz, M. E. and J. C. Clausen (2008). "Stormwater runoff and export changes with development in a traditional and low impact subdivision." Journal of Environmental Management **87**: 560-566.

Development continues at a rapid pace throughout the country. Runoff from the impervious surfaces in these watersheds continues to be a major cause of degradation to freshwater bodies and estuaries. Low impact development techniques have been recommended to reduce these impacts. In this study, stormwater runoff and pollutant concentrations were measured as development progressed in both a traditional development, and a development that used low impact development techniques. Increases in total impervious area in each watershed were also measured. Regression relationships were developed between total impervious area and stormwater runoff/pollutant export. Significant, logarithmic increases in stormwater runoff and nitrogen and phosphorus export were found as development occurred in the traditional subdivision. The increases in stormwater runoff and pollutant export were more than two orders of magnitude. TN and

Donnelly, R. and J. M. Marzluff (2004). "Importance of Reserve Size and Landscape Context to Urban Bird Conservation." Conservation Biology **18**(3): 733-745.

> We tested whether reserve size, landscape surrounding the reserve, and their interaction affect forest songbirds in the metropolitan area of Seattle, Washington (U.S.A.), by studying 29 reserves of varying size (small, medium, large) and surrounding urbanization intensity (urban, suburban, exurban). Larger reserves contained richer and less even bird communities than smaller reserves. These size effects disappeared when we removed the positive correlation of shrub diversity with reserve size, suggesting that greater habitat diversity in large reserves supported additional species, some of which were rare. Standardizing the number of individuals detected among all reserve size classes reversed the effect of size on richness in exurban landscapes and reduced the magnitude of the effect in suburban or urban landscapes. The latter change suggested that richness increased with reserve size in most landscapes because larger areas also supported larger samples from the regional bird species pool. Most bird species associated with native forest habitat (native forest species) and with human activity (synanthropic species) were present in reserves larger than 42 ha and surrounded by >40% urban land cover, respectively. Thus, we recommend these thresholds as means for conserving the composition of native bird communities in this mostly forested region. Native forest specieswere least abundant and synanthropic species most abundant in urban landscapes, where exotic ground and shrub vegetation was most common. Therefore, control of exotic vegetation may benefit native songbird populations. Bird nests in shrubs were most dense in medium (suburban) and large reserves (urban) and tended to be most successful in medium (suburban) and large reserves (exurban), potentially supplying another mechanism by which reserve size increased retention of native forest species.

Doss, C. R. and S. J. Taff (1996). "The Influence of Wetland Type and Wetland Proximity on Residential Property Values." Journal of Agricultural and Resource Economics **21**(1): 120-129.

> Using detailed residential housing and wetland location data, we determine relative preferences for proximity to four broad classes of wetlands, as expressed through housing values. Implicit prices for proximity to open-water and scrub-shrub wetlands are relatively higher than those for emergent-vegetation and forested wetlands.

Duda, A. (1982). "Coastal Pollution from Septic Tank Drainfields." Journal of the Environmental Engineering Division **108**(6): 1265-1279.

Duh, J. D., V. Shandas, et al. (2008). "Rates of urbanisation and the resiliency of air and water quality." Science of The Total Environment **400**: 238-256.

Dwight, R. H., D. B. Baker, et al. (2004). "Health effects associated with recreational coastal water use: Urban versus rural California." American Journal of Public Health **94**: 565-567.

Dwight, R. H., L. M. Fernandez, et al. (2005). "Estimating the economic burden from illnesses associated with recreational coastal water pollution - a case study in Orange County, California." Journal of Environmental Management **76**: 95-103.

Dwight, R. H., J. C. Semenza, et al. (2002). "Association of urban runoff with coastal water quality in Orange County, California." Water Environment Research **74**: 82-90.

Ehrenfeld, J. G. (2000). "Evaluating wetlands within an urban context." Ecological Engineering **15**: 253-265.

Coastal regions are among the most rapidly urbanizing places on earth. The numerous effects of urbanization on hydrology, geomorphology, and ecology make wetlands in urban regions function differently from wetlands in non-urban lands. Furthermore, wetlands in urban regions may take on human-related values that they lack in non-urban areas, as they provide some contact with nature, and some opportunities for recreations that are otherwise rare in the urban landscape. Evaluations of the success of restorations in urban regions require criteria first to determine the kinds, and intensities of urban influence on the site, and secondly to assess functional performance. The development of success criteria, at both the levels of assessment, depends on the proper definition of a reference domain (the set of wetlands to which success criteria will apply), and the documentation of a set of reference sites within the domain; both must be based within the urban context appropriate for the region of interest. An example is presented from a study of urban wetlands in New Jersey of a procedure for establishing the reference domain, the reference set of wetlands, and criteria for the assessment of urban influence. © 2000 Elsevier Science B.V. All rights reserved.

Elmore, A. J. and S. S. Kaushal (2008). "Disappearing headwaters: patterns of stream burial due to urbanization." Frontiers in Ecology and the Environment **6**: 308-312.

Eriksson, E., A. Baun, et al. (2007). "Selected stormwater priority pollutants - a European perspective." Science of The Total Environment **383**: 41-51.

Euliss, N. H., R. A. Gleason, et al. (2006). "North American prairie wetlands are important nonforested land-based carbon storage sites." Science of The Total Environment **361**: 179-188.

We evaluated the potential of prairie wetlands in North America as carbon sinks. Agricultural conversion has resulted in the average loss of 10.1 Mg ha 1 of soil organic carbon on over 16 million ha of wetlands in this region. Wetland restoration has potential to sequester 378 Tg of organic carbon over a 10-year period. Wetlands can sequester over twice the organic carbon as no-till cropland on only about 17% of the total land area in the region. We estimate that wetland

restoration has potential to offset 2.4% of the annual fossil CO2 emission reported for North America in 1990.

Fang, X. and D. H. Su (2006). "An integrated one-dimensional and two-dimensional urban stormwater flood simulation model." Journal of the American Water Resources Association **42**: 713-724.

Fema (2009). HAZUS Analysis for the Green River Valley, FEMA Region X Mitigation**:** 50pp.-50pp.

Howard Hanson Dam, which provides flood control for the Green River, was affected by floods from January 2009, resulting in two depressions at the dam. The dam may have to operate under below normal pool restrictions, which could yield to increased flooding in the Green River valley King County Emergency Management asked FEMA to conduct a HAZUS analysis to determine economic losses, potential shelter requirements and debris generated from a flooding disaster HAZUS used King County GIS data to update building replacement value and square footage. Depth grids provided by USACE, King County, and FEMA were used in HAZUS to calculate losses due to flooding. HAZUS is a modeling tool to estimate losses and could differ greatly from the losses in an actual event. United States Army Corp of Engineers (USACE) created various depth grids resulting from various discharges at the Auburn stream gage, including 13,900, 17,600, 19,000, and 25,000 cfs. The report presented here used the 17,600 cfs depth grid created by USACE. King County also conducted a 100 Year FEMA Flood Study to be included in the preliminary Digital Flood Insurance Rate Map (DFIRM) using a 100 year discharge of 12,800 cfs. The 100 Year flood study also incorporated levee removals to simulate levee failure. This report details analysis for three scenarios which include: Scenario 1 – USACE 17,600 cfs depth grid, Scenario 2 – King County 100 Year DFRIM with a discharge of 12,800 cfs, and Scenario 3 – the USACE 17,600 cfs discharge, with the levee removal scenarios provided in the King County 100 Year DFIRM Results for Scenario 1 include $1.34 billion of economic losses, 35 substantially damage buildings, 15,500 people displaced, and 84,000 tons of debris generated Results for Scenario 2 include $1.97 billion of economic losses, 100 substantially damage buildings, 21,000 people displaced, and 208,000 tons of debris generated Results for Scenario 3 include $3.75 billion of economic losses, 170 substantially damage buildings, 21,000 people displaced, and 280,000 tons of debris generated Levee removal scenarios greatly impact the level of flooding which could be seen. Therefore all levee removals were modeled to simulate levee failure and are used for planning purposes. During the event an individual levee failure could greatly change the flood depth grid. FEMA Region X has released this report to all local and State governments affected by this potential disaster with the hope to better mitigate, plan, prepare, and respond to this pending disaster.

FernÁNdez-Juricic, E. and J. JokimÄKi (2001). "A habitat island approach to conserving birds in urban landscapes: case studies from southern and northern Europe." Biodiversity and Conservation **10**: 2023-2043.

> Wildlife conservation in urban habitats is increasingly important due to current urbanization trends. We review the different approaches to studying birds in urban landscapes, and point out the importance of the habitat island ecological theory as a research framework for the management and conservation of urban birds. Based on two comprehensive research projects conducted at urban parks in Spain (Madrid) and Finland (Oulu and Rovaniemi), several different issues related to bird conservation in cities are discussed, main findings of these projects are presented, and future research needs are suggested. Urban parks are important biodiversity hotspots in cities. Fragmentation conditions have the same deleterious effects to urban birds as in other fragmented landscapes. Park size accounts for species accumulation in urban parks; this pattern being highly nested. Urban parks of 10–35 ha would contain most of the species recorded in cities, but other indicators related to the probabilities of persistence of the target species should be obtained. Wooded streets can increase urban landscape connectivity by providing alternative habitat for feeding and nesting during the breeding season. Because increasing the size of parks is difficult in cities, enhancement of habitat diversity and resource availability for birds within parks (e.g. nest boxes, winter feeding tables, etc.) appears to be a straightforward way of increasing urban bird diversity. However, human disturbance (pedestrians) should be controlled since it can negatively influence many urban birds. We present a conceptual model for urban bird conservation, which includes three aspects (management, environmental education and research) and new alternatives to promote the involvement of different sectors of the society.

Finkenbine, J. K. "STREAM HEALTH AFTER URBANIZATION1. J. K. Finkenbine. 2007; JAWRA Journal of the American Water Resources Association - Wiley InterScience." from http://www3.interscience.wiley.com/journal/119049606/abstract.

> Urban development has compromised the quality of physical elements of fish habitat in low-order spawning and rearing streams. In order to identify where priorities should lie in stream rehabilitation, field surveys of a number of streams were conducted near Vancouver, British Columbia. All of the streams were located in watersheds which were urbanized approximately 20 years earlier. The study watersheds ranged from 5 to 77 percent total impervious area (percent TIA). The urban streambeds were found to have less fine material and slightly higher values of intragravel dissolved oxygen than in rural streams. This improved gravel quality is attributed to the higher peak flows generated by impervious areas, and the reduced recruitment of fine material in the urban watersheds. Summer base flow was uniformly low when imperviousness was above 40 percent, evidenced by a decrease in velocity rather than water depth. Large woody debris (LWD) was scarce in all streams with > 20 percent TIA. A healthy buffer zone and abundant LWD were found to stabilize streambanks. The introduction of LWD is considered the most important strategy for stream rehabilitation. Stormwater

detention ponds, in contrast, are concluded to have few hydrological benefits if constructed after a stream has reached its urban equilibrium.

Finkenbine, J. K., J. W. Atwater, et al. (2000). "STREAM HEALTH AFTER URBANIZATION¹." Journal of the American Water Resources Association **36**(5): 1149-1160.

Urban development has compromised the quality of physical elements offish habitat in low-order spawning and rearing streams. In order to identify where priorities should lie in stream rehabilitation, field surveys of a number of streams were conducted near Vancouver, British Columbia. All of the streams were located in watersheds which were urbanized approximately 20 years earlier. The study watersheds ranged from 5 to 77 percent total impervious area (percent TIA). The urban streambeds were found to have less fine material and slightly higher values of intragravel dissolved oxygen than in rural streams. This improved gravel quality is attributed to the higher peak flows generated by impervious areas, and the reduced recruitment of fine material in the urban watersheds. Summer base flow was uniformly low when imperviousness was above 40 percent, evidenced by a decrease in velocity rather than water depth. Large woody debris (LWD) was scarce in all streams with > 20 percent TIA. A healthy buffer zone and abundant LWD were found to stabilize stream banks. The introduction of LWD is considered the most important strategy for stream rehabilitation. Stormwater detention ponds, in contrast, are concluded to have few hydrological benefits if constructed after a stream has reached its urban equilibrium.

Fitzpatrick, F. A., M. A. Harris, et al. (2004). "Urbanization influences on aquatic communities in northeastern Illinois streams." Journal of the American Water Resources Association **40**(2): 461-476.

Foltz, S. J. and S. I. Dodson (2009). "Aquatic Hemiptera community structure in stormwater retention ponds: a watershed land cover approach." Hydrobiologia **621**: 49-62.

Stormwater ponds are increasingly common aquatic habitats whose biotic communities are largely unexplored. As anthropogenic development continues to alter the landscape, watershed land use is gaining recognition for its potential to predict species compositions in aquatic systems. This study reports species composition of five aquatic hemipteran families (Notonectidae, Corixidae, Belostomatidae, Nepidae, Pleidae) in 28 permanent, artificial stormwater ponds in watersheds with different land covers and associated contaminant input. We hypothesized that land cover variables would be significant drivers of aquatic hemipteran community structure in ponds, and that ponds with a high percentage of agricultural and lawn cover in the watershed would be characterized by the absence of species intolerant of the chemical, physical, and ultimately biotic changes associated with these watersheds. Non-metric multi-dimensional scaling (NMS) was used to identify dominant gradients of species composition and environmental variables. Pond morphology variables, watershed lawn, watershed

agriculture, and predatory fish abundance were each found to have statistically significant correlations with hemipteran community structure. The abundance of Notonecta undulata, the species responsible for creating the largest (ranked) distance in species structure among ponds, was positively correlated with shallow, fishless ponds and independent of land use variables. The abundances of four species of corixids were negatively correlated with watershed agriculture, and hemipteran richness was positively correlated with watershed lawn and negatively correlated with pond surface area. Heirarchical cluster analysis revealed non-random hemipteran species assemblages in which congeneric corixid species tended to co-occur, contradicting traditional niche theory. Since artificial stormwater ponds are chemically different from natural-pond habitat and rapidly increasing in number, knowledge of which insect species are capable of thriving in this environment and their relationship to land use in the watershed is of both environmental and evolutionary interest.

Gaffield, S. J., R. L. Goo, et al. (2003). "Public health effects of inadequately managed stormwater runoff." American Journal of Public Health **93**: 1527-1533.

Galster, J. C., F. J. Pazzaglia, et al. (2008). "Measuring the impact of urbanization on channel widths using historic aerial photographs and modern surveys." Journal of the American Water Resources Association **44**: 948-960.

Gardner, C. B. and A. E. Carey (2004). "Trace metal and major ion inputs into the Olentangy River from an urban storm sewer." Environmental Science & Technology **38**: 5319-5326.

Gilroy, K. L. and R. H. McCuen (2009). "Spatio-temporal effects of low impact development practices." Journal of Hydrology **367**(3/4): 228-236.

Summary: The increase in land development and urbanization experienced in the US and worldwide is causing environmental degradation. Traditional off-site stormwater management does not protect small streams. To mitigate the negative effects of land development, best management practices (BMPs) are being implemented into stormwater management policies for the purposes of controlling minor flooding and improving water quality. Unfortunately, the effectiveness of BMPs has not been extensively studied. The purpose of this research was to analyze the effects of both location and quantity of two types of BMPs: cisterns and bioretention pits. A spatio-temporal model of a microwatershed was developed to determine the effects of BMPs on single-family, townhome, and commercial lots. The effects of development and the BMPs on peak runoff rates and volumes were compared to pre-development conditions. The results show that cisterns alone are capable of controlling rooftop runoff for small storms. Both the spatial location and the volume of BMP storage on a microwatershed influences the effectiveness of BMPs. The volume of BMP storage is positively correlated to the percent reduction in the peak discharge rate and total runoff volume; however, location is a factor in the peak reduction and a maximum volume of effective

storage for both hydrologic metrics does exist. These results provide guidelines for developing stormwater management policies that can potentially reduce pollution of first-order streams, lower the cost and maintenance requirements, enhance aesthetics, and increase safety. [Copyright &y& Elsevier]

Glasoe, S. and A. Christy (2004). "Literature Review and Analysis: Coastal Urbanization and Microbial Contamination of Shellfish Growing Areas." Puget Sound Action Team Publication# PSAT04-09 **1**(2): 3-3.

Gobel, P., C. Dierkes, et al. (2007). "Storm water runoff concentration matrix for urban areas." Journal of Contaminant Hydrology **91**: 26-42.

Goulding, G. M. and Z. F. Hu (2009). "Urban Wet-Weather Flows." Water Environment Research **81**: 1003-1055.

Grable, J. L. and C. P. Harden (2006). "Geomorphic response of an Appalachian Valley and Ridge stream to urbanization." Earth Surface Processes and Landforms **31**: 1707-1720.

Graf, W. L. (1975). "The Impact of Suburbanization on Fluvial Geomorphology." Water Resources Research **11**(5): 690-692.

Gregory, K. J. and A. Chin (2002). "Urban stream channel hazards." Area **34**: 312-321.

Griffith, J., S. Weisberg, et al. (2003). "Evaluation of microbial source tracking methods using mixed fecal sources in aqueous test samples." from http://www.iwaponline.com/jwh/001/jwh0010141.htm.

Guo, J. C. Y. (2010). "Preservation of Watershed Regime for Low-Impact Development through Detention." Journal of Hydrologic Engineering **15**: 15-19.

Hall, S. J., B. Ahmed, et al. (2009). "Urbanization Alters Soil Microbial Functioning in the Sonoran Desert." Ecosystems **12**: 654-671.

Hammer, T. R. "Stream Channel Enlargement Due to Urbanization." Water Resources Research **8**(6): PP. 1530-1540-PP. 1530-1540.

Heaton, R. (1981). "Wastewater reclamation and reuse." GeoJournal **5**(5): 483-501.
Municipal wastewater reclamation and reuse has been practiced for hundreds of years as a beneficial use of a previously wasted product. But it is now becoming recognized as an effective water conservation tool and pollution-control method. This paper describes the status, need, and potential of water reuse in the United States. Current policies are emphasized with several examples of successful water recycling on a worldwide basis given. The discussion is limited to the treatment and reuse of municipal sewage effluents for agricultural, industrial, recreational

and domestic purposes. This is to be distinguishedfrom in-plant water recycling where multiple uses of the same water are evident.

Hejazi, M. I. and M. Markus (2009). "Impacts of Urbanization and Climate Variability on Floods in Northeastern Illinois." Journal of Hydrologic Engineering **14**(6): 606-616.

Helfield, J. A. and M. L. Diamond (1997). "Use of Constructed Wetlands for Urban Stream Restoration: A Critical Analysis." Environmental Management **21**(3): 329-341.

Investigation of a delta marsh restoration project proposed for the Don River in Toronto, Ontario, underlines several concerns about constructed wetland projects designed for water quality improvement and aquatic habitat enhancement. The Don is a highly urbanized river that has undergone significant physiographic modifications and continually receives a complex mixture of conventional, metallic, and organic contaminants from multiple point and nonpoint sources. Rather than providing permanent removal of urban contaminants, wetland processes offer a limited capacity for temporary storage of contaminant inputs, and potential reactions may actually produce more toxic and/or bioavailable forms of some chemicals. These processes tend to result in the concentration of watershed contaminants in wetland vegetation and sediments. As the restored marsh would be available for spawning and feeding by aquatic fauna, the potential exists for chemical bioconcentration and biomagnification through the aquatic community. Accordingly, wetland systems are not suited to the dual purposes of water quality improvement and aquatic habitat enhancement. Upstream controls, including source reduction of contaminant inputs, are recommended as essential components of all constructed wetland projects.

Helms, B. S., J. E. Schoonover, et al. (2009). "ASSESSING INFLUENCES OF HYDROLOGY, PHYSICOCHEMISTRY, AND HABITAT ON STREAM FISH ASSEMBLAGES ACROSS A CHANGING LANDSCAPE." Journal of the American Water Resources Association **45**: 157-169.

Henshaw, P. C. and D. B. Booth (2000). "NATURAL RESTABILIZATION OF STREAM CHANNELS IN URBAN WATERSHEDS¹." Journal of the American Water Resources Association **36**(6): 1219-1236.

Stream channels are known to change their form as a result of watershed urbanization, but do they restabilize under subsequent conditions of constant urban land use? Streams in seven developed and developing watersheds (drainage areas 5201335 km2) in the Puget Sound lowlands were evaluated for their channel stability and degree of urbanization, using field and historical data. Protocols for determining channel stability by visual assessment, calculated bed mobility at bankfull flows, and resurveyed cross-sections were compared and yielded nearly identical results. We found that channel restabilization generally does occur within one or two decades of constant watershed land use, but it is not universal. When (or if) an individual stream will restabilize depends on specific hydrologic and geomorphic characteristics of the channel and its watershed; observed

stability is not well predicted by simply the magnitude of urban development or the rate of ongoing land-use change. The tendency for channel restabilization suggests that management efforts focused primarily on maintaining stability, particularly in a still-urbanizing watershed, may not always be necessary. Yet physical stability alone is not a sufficient condition for a biologically healthy stream, and additional rehabilitation measures will almost certainly be required to restore biological conditions in urban systems.

Herb, W. R., B. Janke, et al. (2008). "Ground surface temperature simulation for different land covers." Journal of Hydrology **356**: 327-343.

Herngren, L., A. Goonetilleke, et al. (2005). "Understanding heavy metal and suspended solids relationships in urban stormwater using simulated rainfall." Journal of Environmental Management **76**: 149-158.

Holman-Dodds, J. K., A. A. Bradley, et al. (2003). "Evaluation of hydrologic benefits of infiltration based urban storm water management." Journal of the American Water Resources Association **39**(1): 205-215.

ABSTRACT: As watersheds are urbanized, their surfaces are made less pervious and more channelized, which reduces infiltration and speeds up the removal of excess runoff. Traditional storm water management seeks to remove runoff as quickly as possible, gathering excess runoff in detention basins for peak reduction where necessary. In contrast, more recently developed “low impact” alternatives manage rainfall where it falls, through a combination of enhancing infiltration properties of pervious areas and rerouting impervious runoff across pervious areas to allow an opportunity for infiltration. In this paper, we investigate the potential for reducing the hydrologic impacts of urbanization by using infiltration based, low impact storm water management. We describe a group of preliminary experiments using relatively simple engineering tools to compare three basic scenarios of development: an undeveloped landscape; a fully developed landscape using traditional, high impact storm water management; and a fully developed landscape using infiltration based, low impact design. Based on these experiments, it appears that by manipulating the layout of urbanized landscapes, it is possible to reduce impacts on hydrology relative to traditional, fully connected storm water systems. However, the amount of reduction in impact is sensitive to both rainfall event size and soil texture, with greatest reductions being possible for small, relatively frequent rainfall events and more pervious soil textures. Thus, low impact techniques appear to provide a valuable tool for reducing runoff for the events that see the greatest relative increases from urbanization: those generated by the small, relatively frequent rainfall events that are small enough to produce little or no runoff from pervious surfaces, but produce runoff from impervious areas. However, it is clear that there still needs to be measures in place for flood management for larger, more intense, and relatively rarer storm events, which are capable of producing significant runoff even for undeveloped basins.

Hood, M. J., J. C. Clausen, et al. (2007). "Comparison of stormwater lag times for low impact and traditional residential development." Journal of the American Water Resources Association **43**: 1036-1046.

Horner, R., C. May, et al. (1999). Impervious Cover, Aquatic Community Health, and Storm water BMPs: Is There a Relationship?, Southwest Florida Water Management District, Tampa, Florida.

> Research during the past 10 years has showed that the health of aquatic biological communities declines with increasing levels of watershed imperviousness. The hypothesis tested in this project was that the use of structural and nonstructural stormwater BMPs will allow a healthier biological community at higher levels of imperviousness. To test this hypothesis bioassessments were performed in Montgomery County, Maryland, Austin, Texas, Vail, Colorado, and the Puget Sound area of Washington. This paper will report primarily on the findings from the Puget Sound area where lowland salmon spawning and rearing streams and their watersheds were studied to identify the linkages between watershed conditions, specifically urbanization, and the habitat elements and biological responses. The study's intent was to produce a knowledge base for managing land with reference to ecological protection goals. Measures of benthic macroinvertebrate and fish community integrity declined from the lowest levels of urbanization without exhibiting a threshold effect, although retention of natural riparian buffer partially ameliorated the decline of invertebrates. The study produced a set of conditions necessary to preserve the highest levels of biological integrity or avoid the lowest. A follow-up study is in progress to assess the influence of structural and nonstructural best management practices (BMPs) on the same ecological communities. Results to date demonstrate that retention of a wide, nearly continuous riparian buffer in native vegetation has greater and more flexible potential than other options to uphold biological integrity when development increases. Upland forest retention also offers valuable benefits, especially in managing any development occurring in previously undeveloped or lightly developed watersheds. Structural BMPs have less mitigation potential than the non-structural BMPs assessed and should not be regarded, as they so often are, as the leading or even the single strategy. Still, they have their place in management, especially in moderately and highly developed watersheds, to help prevent further resource deterioration, and, in dense networks along with non-structural means, in less developed basins of relatively high ecological value and sensitivity. None of the options is without limitations, and widespread landscape preservation must be incorporated if we are to keep the most productive aquatic resources in the Puget Sound region. While circumstances differ in other settings, the methods used and general conclusions likely have wide applicability.

Hwang, H. M. and G. D. Foster (2008). "Polychlorinated biphenyls in stormwater runoff entering the tidal Anacostia River, Washington, DC, through small urban catchments and combined sewer outfalls." Journal of Environmental Science and Health Part a-Toxic/Hazardous Substances & Environmental Engineering **43**: 567-575.

In, S. J., K. M. Brannan, et al. (2003). "Simulating hydrologic and water quality impacts in an urbanizing watershed." Journal of the American Water Resources Association **39**: 1465-1479.

Jacobson, M. Z. (2010). "Enhancement of Local Air Pollution by Urban CO2 Domes." Environmental Science & Technology **44**(7): 2497-2502.

> Data suggest that domes of high CO2 levels form over cities. Despite our knowledge of these domes for over a decade, no study has contemplated their effects on air pollution or health. In fact, all air pollution regulations worldwide assume arbitrarily that such domes have no local health impact, and carbon policy proposals, such as “cap and trade”, implicitly assume that CO2 impacts are the same regardless of where emissions occur. Here, it is found through data-evaluated numerical modeling with telescoping domains from the globe to the U.S., California, and Los Angeles, that local CO2 emissions in isolation may increase local ozone and particulate matter. Although health impacts of such changes are uncertain, they are of concern, and it is estimated that that local CO2 emissions may increase premature mortality by 50−100 and 300−1000/yr in California and the U.S., respectively. As such, reducing locally emitted CO2 may reduce local air pollution mortality even if CO2 in adjacent regions is not controlled. If correct, this result contradicts the basis for air pollution regulations worldwide, none of which considers controlling local CO2 based on its local health impacts. It also suggests that a “cap and trade” policy should consider the location of CO2 emissions, as the underlying assumption of the policy is incorrect.

Joyce, J. M. and M. S. Scott An Assessment Of Maryland’s Vulnerability To Flood Damage.

Kang, R. S. and R. A. Marston (2006). "Geomorphic effects of rural-to-urban land use conversion on three streams in the central Redbed Plains of Oklahoma." Geomorphology **79**: 488-506.

Karthikeyan, K. G. and M. T. Meyer (2006). "Occurrence of antibiotics in wastewater treatment facilities in Wisconsin, USA." Science of The Total Environment **361**(1-3): 196-207.

> Samples from several wastewater treatment facilities in Wisconsin were screened for the presence of 21 antibiotic compounds. These facilities spanned a range of community size served (average daily flow from 0.0212 to 23.6 million gallons/day), secondary treatment processes, geographic locations across the state, and they discharged the treated effluents to both surface and ground waters (for ground water after a soil passage). A total of six antibiotic compounds were detected (1-5 compounds per site), including two sulfonamides (sulfamethazine, sulfamethoxazole), one tetracycline (tetracycline), fluoroquinolone (ciprofloxacin), macrolide (erythromycin-H2O) and trimethoprim. The frequency

of detection of antibiotics was in the following order: tetracycline and trimethoprim (80%) > sulfamethoxazole (70%) > erythromycin-H2O (45%) > ciprofloxacin (40%) > sulfamethazine (10%). However, the soluble concentrations were in the parts-per-billion (ppb) range (<= 1.3 [mu]g/L), and importantly were unaffected by the size of the wastewater treatment facility. The concentrations detected were within an order of magnitude of those reported for similar systems in Europe and Canada: they were within a factor of two in comparison to those reported for Canada but generally lower relative to those measured in wastewater systems in Europe. Only sulfamethoxazole and tetracycline were detected in groundwater monitoring wells adjacent to the treatment systems. Future intensive wastewater monitoring programs in Wisconsin may be limited to the six antibiotic compounds detected in this study.

Kauffman, G. J., A. C. Belden, et al. (2009). "Link between Impervious Cover and Base Flow in the White Clay Creek Wild and Scenic Watershed in Delaware." Journal of Hydrologic Engineering **14**: 324-334.

Kaye, J., P. Groffman, et al. (2006). "A distinct urban biogeochemistry?" Trends in Ecology & Evolution **21**(4): 192-199.

Kayranli, B., M. Scholz, et al. "Carbon Storage and Fluxes within Freshwater Wetlands: a Critical Review." Wetlands **30**: 111-124.

We critically review recent literature on carbon storage and fluxes within natural and constructed freshwater wetlands, and specifically address concerns of readers working in applied science and engineering. Our purpose is to review and assess the distribution and conversion of carbon in the water environment, particularly within wetland systems. A key aim is to assess if wetlands are carbon sinks or sources. Carbon sequestration and fluxes in natural and constructed wetlands located around the world has been assessed. All facets of carbon (solid and gaseous forms) have been covered. We draw conclusions based on these studies. Findings indicate that wetlands can be both sources and sinks of carbon, depending on their age, operation, and the environmental boundary conditions such as location and climate. Suggestions for further research needs in the area of carbon storage in wetland sediments are outlined to facilitate the understanding of the processes of carbon storage and removal and also the factors that influence them.

Keen-Zebert, A. (2007). "Channel Responses to Urbanization: Scull and Mud Creeks in Fayetteville, Arkansas." Physical Geography **28**(3): 249-260.

Urbanization has several effects on the controls on stream morphology. In order to provide a basis for future study, and to determine whether changes in urban stream-channel morphology can be detected in a short time period, two urban streams in Fayetteville, Arkansas were chosen for repeat cross-section measurement and suspended sediment sampling over 18 months. Standard U.S. Geological Survey measurement and sampling techniques were used. An overall

decrease in mean depth was observed over the study period. Significant channel variation occurred where there was ongoing development and channel obstruction. Channel stability was observed in locations with diverse riparian vegetation. Channel shape varied with land use in the study area. Sites with more disturbances in the near-channel environment were variable over the course of the study, exhibiting a complex response to several types of disturbances.

King, R. S., W. V. Deluca, et al. (2007). "Threshold effects of coastal urbanization on Phragmites australis (common reed) abundance and foliar nitrogen in Chesapeake Bay." Estuaries and Coasts **30**: 469-481.

Knutson, M. G., J. R. Sauer, et al. (1999). "Effects of Landscape Composition and Wetland Fragmentation on Frog and Toad Abundance and Species Richness in Iowa and Wisconsin, U.S.A." Conservation Biology **13**(6): 1437-1446.

Management of amphibian populations to reverse recent declines will require defining high-quality habitat for individual species or groups of species, followed by efforts to retain or restore these habitats on the landscape. We examined landscape-level habitat relationships for frogs and toads by measuring associations between relative abundance and species richness based on survey data derived from anuran calls and features of land-cover maps for Iowa and Wisconsin. The most consistent result across all anuran guilds was a negative association with the presence of urban land. Upland and wetland forests and emergent wetlands tended to be positively associated with anurans. Landscape metrics that represent edges and patch diversity also had generally positive associations, indicating that anurans benefit from a complex of habitats that include wetlands. In Iowa the most significant associations with relative abundance were the length of the edge between wetland and forest (positive) and the presence of urban land (negative). In Wisconsin the two most significant associations with relative abundance were forest area and agricultural area (both positive). Anurans had positive associations with agriculture in Wisconsin but not in Iowa. Remnant forest patches in agricultural landscapes may be providing refuges for some anuran species. Differences in anuran associations with deep water and permanent wetlands between the two states suggest opportunities for management action. Large-scale maps can contribute to predictive models of amphibian habitat use, but water quality and vegetation information collected from individual wetlands will likely be needed to strengthen those predictions. Landscape habitat analyses provide a framework for future experimental and intensive research on specific factors affecting the health of anurans.

Konrad, C. P. and D. B. Booth (2005). Hydrologic changes in urban streams and their ecological significance.

Konrad, C. P., D. B. Booth, et al. (2005). "Effects of urban development in the Puget Lowland, Washington, on interannual streamflow patterns: Consequences for channel form and streambed disturbance." Water Resources Research **41**.

Kurn, D. M., S. E. Bretz, et al. The potential for reducing urban air temperatures and energy consumption through vegetative cooling, Lawrence Berkeley Lab., CA (United States).

> A network of 23 weather stations was used to detect existing oases in Southern California. Four stations, separated from one another by 15--25 miles (24--40 km), were closely examined. Data were strongly affected by the distance of the stations from the Pacific Ocean. This and other city-scale effects made the network inadequate for detection of urban oases. We also conducted traverse measurements of temperature and humidity in the Whittier Narrows Recreation Area in Los Angeles County on September 8--10, 1993. Near-surface air temperatures over vegetated areas were 1--2{degrees}C lower than background air temperatures. We estimate that vegetation may lower urban temperatures by 1{degrees}C, while the establishment of vegetative canopies may lower local temperatures by an additional 2{degrees}C. An increase in vegetation in residential neighborhoods may reduce peak loads in the Los Angeles area by 0.3 GW, and reduce energy consumption by 0.2 BkWh/year, saving $20 million annually. Large additional savings would result from regional cooling.

Lee, H., S. L. Lau, et al. (2004). "Seasonal first flush phenomenon of urban stormwater discharges." Water Research **38**: 4153-4163.

Lee, J. S. and M.-H. Li (2009). "The impact of detention basin design on residential property value: Case studies using GIS in the hedonic price modeling." Landscape and Urban Planning **89**(1-2): 7-16.

> This study examined the impact of two different detention basin designs on residential property value. The hedonic price model was applied to analyze two College Station, TX, subdivisions. One subdivision had only uniuse flood control detention basins (UDBs) and the other included a multi-use detention basin (MDB) integrating a detention pond with a recreational neighborhood park. Geographic information system (GIS) was used for analysis. Spatial autocorrelation and spatial regression were analyzed. The results indicate that the network distance from the UDBs did not have a significant effect on residential property value. Yet, the properties with a view of the UDBs were significantly lowered in property value. In contrast, the network distance from the MDB where a neighborhood park was merged had a significant impact on residential property value within the 274-m (900-ft) impact area, consistent with expectations. The study also found that environmental amenities such as recreational facilities improved the hedonic price model for the impact area of the MDB, whereas the effect of spatial and locational features was not significant due to its spatial location. The findings of this study imply that thoughtful integration between recreation facilities and detention basins could significantly alter public's perception of detention basins from stormwater collection eyesores to neighborhood parks. The challenge is whether municipal governments are willing to adopt a policy that encourages developments with MDBs as these

municipalities will typically become responsible for maintaining them after construction.

Leopold, L. B. (1973). "River Channel Change with Time: An Example: Address as Retiring President of The Geological Society of America, Minneapolis, Minnesota, November 1972." Geological Society of America Bulletin **84**(6): 1845-1860.

Monumented channel cross sections were resurveyed over a period of 20 yrs (1953 to 1972) to determine the amount and kind of change of channel area and position on a 3.7-sq-mi basin, Watts Branch near Rockville, Maryland. For the first 12 yrs, the channel progressively but slowly became smaller as urbanization of the basin gradually proceeded. After 1966, a threshold of change apparently was passed and, probably as a result of an increased rate of land alteration upstream, large amounts of sediment were deposited within the channel and overbank. The number of floods exceeding channel capacity increased dramatically from an average of two to more than ten per year. Simultaneously, the channel area began to increase. Despite the trend toward increasing cross-sectional area, the net result after 20 yrs was a channel smaller by 20 percent than it had been originally. Urbanization did not alter the rate of channel migration.

Leopold, L. B., R. Huppman, et al. (2005). "Geomorphic effects of urbanization in forty-one years of observation." Proceedings of the American Philosophical Society **149**: 349-371.

Line, D. E. and N. M. White (2007). "Effects of development on runoff and pollutant export." Water Environment Research **79**: 185-190.

Lloyd, S., T. H. F. Wong, et al. (2002). Water sensitive urban design : a stormwater management perspective / Sara D. Lloyd, Tony H. F. Wong and Christopher J. Chesterfield. Clayton, Vic. :, CRC for Catchment Hydrology.

Lopes, T. J. and D. A. Bender (1998). "Nonpoint sources of volatile organic compounds in urban areas - relative importance of land surfaces and air." Environmental Pollution **101**: 221-230.

Lovett, G. M. (1994). "Atmospheric deposition of nutrients and pollutants in North America: An ecological perspective." Ecological Applications **4**(4): 629-650.

Research on air pollution and acidic deposition during the last 15 yr has greatly increased our knowledge of the rates and the processes of atmospheric deposition. The invigoration of the field has been a direct result of interchange and cooperation among ecosystem ecologists, micrometeorologists, and plant physiological ecologists who each approach the study of atmospheric deposition from different perspectives. This has led to the widespread realization among ecologists of the importance of dry and cloud deposition and the introduction of new methods to estimate these fluxes. In this paper I summarize the current understanding of atmospheric deposition processes, measurement methods, and

patterns of deposition in North America. Dry deposition measurements are still highly uncertain in most cases, and methodology is still an active area of research and debate, but it seems clear that ecologists will require a suite of different methods to evaluate dry deposition fluxes of the various elements important to ecosystems. Standard model formulations have been developed for estimating dry and cloud deposition, and these models are finding wide use in flux estimation at sites where direct measurements are unavailable. National monitoring networks for wet and dry deposition have been established and are providing information on continental- and regional-scale patterns. Research has demonstrated that deposition rates are increased substantially at high-elevation sites by enhancement of wet, dry, and, especially, cloud deposition. Patterns of O sub(3) exposure are also different at high-elevation sites. The deposition of O sub(3), while mechanistically similar to that of other gases, has been treated differently in the ecological and botanical literature because of its direct phytotoxicity at ambient concentrations in industrialized areas. Current efforts in ozone exposure research involve determining appropriate exposure indices for interpreting biological responses and coupling models of atmospheric transport with models of ozone disposition within the plant.

Maestre, A. and R. Pitt (2005). The National Stormwater Quality Database, Version 1.1, A Compilation and Analysis of NPDES Stormwater Monitoring Information. Washington, D.C., U.S. EPA, Office of Water.

Mahan, B. L., P. Polasky, et al. (2000). "Valuing Urban Wetlands: A property price approach." Land Economics **76**(1): 100-113.

This study estimates the value of wetland amenities in the Portland, Oregon, metropolitan area using the hedonic property price model. Residential housing and wetland data are used to relate the sales price of a property to structural characteristics, neighborhood attributes, and amenities of wetlands and other environmental characteristics. Measures of interest are distance to and size of wetlands, including distancet of our different wetland types; open water, emergent vegetation, scrub-shrub, and forested. Other environmental variables include proximity to parks,lakes, streams, and rivers. Results indicate that wetlands influence the value of residential property and that wetlands influence property values differently than other amenities. Increasing the size of the nearest wetland to a residence by one acre increased the residence's value by $24. Similarly, reducing the distance to the nearest wetland by 1,000 feet increased the value by $436. Home values were not influenced by wetland type.

Mahan, C. G. and T. J. O'Connell (2005). "Small mammal use of surburban and urban parks in central Pennsylvania." Northeastern Naturalist **12**(3): 307-314.

To assist land managers responsible for park management, we conducted a pilot study to examine small mammal assemblages at 7 riparian parks in suburban/ urban landscapes and at 1 riparian site in mature forest, all located in central Pennsylvania. Species richness and diversity were lowest in parks containing

manicured habitats and surrounded by human-modified landscapes. However, parks managed for passive recreation supported mammalian assemblages that were similar in richness and diversity to our mature riparian forest site. The mature riparian forest site contained four species of small mammals (eastern chipmunks [Tamias striatus], white-footed mice [Peromyscus leucopus], deer mice [P. maniculatus], and woodland jumping mice [Napeozapus insignis]), and Spring Creek Nature Park, a park managed to promote natural and native habitats, contained five species (short-tailed shrews [Blarina brevicauda], eastern chipmunks, white-footed mice, meadow voles [Microtus pennsylvanicus], and meadow jumping mice [Zapus hudsonius]). In contrast, parks located in more urban settings and consisting primarily of mowed habitat contained only 1 or 2 species of small mammals. We did not capture non-native species in our study. Based upon this study, we recommend locating parks along streams or other natural corridors, leaving unmowed 10–15-m buffers along streams, and planting native trees along stream corridors in order to encourage diversity of small mammals in suburban and urban parks.

Makepeace, D. K., D. W. Smith, et al. (1995). "URBAN STORMWATER QUALITY - SUMMARY OF CONTAMINANT DATA." Critical Reviews in Environmental Science and Technology **25**: 93-139.

Mallin, M. A., S. H. Ensign, et al. (2001). "Demographic, landscape, and meteorological factors controlling the microbial pollution of coastal waters." Hydrobiologia **460**(1): 185-193.

Mallin, M. A., V. L. Johnson, et al. (2009). "Comparative impacts of stormwater runoff on water quality of an urban, a suburban, and a rural stream." Environmental Monitoring and Assessment **159**: 475-491.

Mallin, M. A., K. E. Williams, et al. (2000). "EFFECT OF HUMAN DEVELOPMENT ON BACTERIOLOGICAL WATER QUALITY IN COASTAL WATERSHEDS." Ecological Applications **10**(4): 1047-1056.

Maltby, L., D. M. Forrow, et al. (1995). "THE EFFECTS OF MOTORWAY RUNOFF ON FRESH-WATER ECOSYSTEMS .1. FIELD-STUDY." Environmental Toxicology and Chemistry **14**: 1079-1092.

Manuel, P. M. (2003). "CULTURAL PERCEPTIONS OF SMALL URBAN WETLANDS: CASES FROM THE HALIFAX REGIONAL MUNICIPALITY, NOVA SCOTIA, CANADA." Wetlands **23**: 921-940.

Urban wetlands, despite their imperfections, provide natural and aesthetic landscape diversity in the built environment. We are beginning to understand and document the ecological significance of this diversity and the management challenges presented by the urban context. The cultural significance of urban wetlands has not received similar attention. The research presented in this paper

explores the relationship between people and wetlands in local neighborhood settings. We surveyed residents of three urban communities in the Halifax Regional Municipality, Nova Scotia, Canada for their knowledge about and perceptions of a small wetland in each of their respective neighborhoods. Results of the survey show that the study participants are aware of the wetlands in their midst but are not especially observant of or knowledgeable about 'their' sites, nor do they visit their wetlands regularly. Yet, despite this apparent disinterest, they readily identify the wetlands as part of their neighborhoods and as assets, especially as natural features and habitat for urban wildlife. The study participants do not consider these neighborhood wetlands nuisance environments or a waste of land. Instead, respondents revealed an appreciation of the aesthetic attributes and habitat value of wetlands in the city and of urban natural spaces.

May, D. B. and M. Sivakumar (2009). "Prediction of heavy metal concentrations in urban stormwater." Water and Environment Journal **23**: 247-254.

McBride, M. and D. B. Booth (2005). "Urban impacts on physical stream condition: Effects of spatial scale, connectivity, and longitudinal trends." Journal of the American Water Resources Association **41**: 565-580.

McCarthy, D. T., V. G. Mitchell, et al. (2007). "Escherichia coli in urban stormwater: explaining their variability." Water Science and Technology **56**: 27-34.

McConnell, V. and M. Walls (2005). THE VALUE OF OPEN SPACE: EVIDENCE FROM STUDIES OF NONMARKET BENEFITS, Resources for the Future.

Open space provides a range of benefits to citizens of a community, beyond the benefits that accrue to private landowners. Parks and natural areas can be used for recreation; wetlands and forests supply storm-water drainage and wildlife habitat; farms and forests provide aesthetic benefits to surrounding residents. And in rapidly growing urban and suburban areas, any preserved land can offer relief from congestion and other negative effects of development. It is one thing to recognize that open space provides these benefits but quite another to place a monetary value on them. To make important policy and planning decisions about zoning, restrictions on land use, government purchase of lands for parks, and similar initiatives, however, estimates of preferences and even dollar values can be essential. In this study, we review more than 60 published articles that have attempted to estimate the value of different types of open space. The two major approaches for estimating open space value from the economics literature are the focus of this study: revealed preference methods and stated preference methods. In the first category are hedonic property value studies in which the open space value is inferred by estimating the sales price or value of a property as a function of measures of proximity to open space and other property and neighborhood characteristics. In the second are studies that use carefully designed surveys to elicit preferences or values households place on various types of open space amenities. Both contingent valuation and contingent choice studies are reviewed.

Both the revealed and stated preference studies generally show that there is value to preserving most types of open space land uses, but the values tend to vary widely with the size of the area, the proximity of the open space to residences, the type of open space, and the method of analysis. One conclusion we draw from this review is that the extant literature tends to be case study specific. However, it is possible to draw conclusions from the range of studies about the direction of particular effects, how values vary by location and other influences, and the differences among the methodologies used to estimate values. In addition, we suggest areas where additional research is needed to improve valuation estimates. We also conclude that more analysis is needed about how to conduct studies with broader applicability.

McKinney, M. L. (2002). "Urbanization, Biodiversity, and Conservation." Bioscience **52**(10): 883-890.

The impacts of urbanization on native species are poorly studied, but educating a highly urbanized human population about these impacts can greatly improve species conservation in all ecosystems

McPherson, E., E. Gregory, et al. (1999). Carbon dioxide reduction through urban forestry: guidelines for professional and volunteer tree planters, U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station**:** 237pp-237pp.

Carbon dioxide reduction through urban forestry—Guidelines for professional and volunteer tree planters has been developed by the Pacific Southwest Research Station's Western Center for Urban Forest Research and Education as a tool for utilities, urban foresters and arborists, municipalities, consultants, non-profit organizations and others to determine the effects of urban forests on atmospheric carbon dioxide (CO2) reduction. The calculation of CO2 reduction that can be made with the use of these Guidelines enables decision makers to incorporate urban forestry into their efforts to protect our global climate. With these Guidelines, they can: report current and future CO2 reductions through a standardized accounting process; evaluate the cost-effectiveness of urban forestry programs with CO2 reduction measures; compare benefits and costs of alternative urban forestry program designs; and produce educational materials that assess potential CO2 reduction benefits and provide information on tree selection, placement, planting, and stewardship

McPherson, E. G., D. Nowak, et al. (1997). "Quantifying urban forest structure, function, and value: the Chicago Urban Forest Climate Projec." Urban Ecosystems **1**(1): 49-61.

This paper is a review of research in Chicago that linked analyses of vegetation structure with forest functions and values. During 1991, the regions trees removed an estimated 5575 metric tons of air pollutants, providing air cleansing worth 9.2 million. Each year they sequester an estimated 315 800 metric tons of carbon. Increasing tree cover 10% or planting about three trees per building lot saves annual heating and cooling costs by an estimated 50 to 90 per dwelling unit because of increased shade, lower summertime air temperatures, and reduced

neighborhood wind speeds once the trees mature. The net present value of the services trees provide is estimated as 402 per planted tree. The present value of long-term benefits is more than twice the present value of costs.

Meays, C. L., K. Broersma, et al. (2004). "Source tracking fecal bacteria in water: a critical review of current methods." Journal of Environmental Management **73**(1): 71-79.

Many molecular and biochemical methods and techniques are being developed to track sources of bacteria in water and food. Currently, there is no standard method proposed for source tracking. This manuscript is a critical evaluation of the various methods used in watersheds, and highlights some of the advantages and disadvantages of each method. Making a decision on a single or combination of methods to use under a particular situation will depend on a number of factors including: question(s) to be answered, scale of identification (broad scale versus specific species identification), available expertise, cost of analysis, turnaround time, and access to facilities. This manuscript reviews several source tracking methodologies which are in current use for source tracking fecal bacteria in the environment including: ribotyping, pulse-field gel electrophoresis, denaturing-gradient gel electrophoresis, repetitive DNA sequences (Rep-PCR), host-specific 16S rDNA genetic markers, and antibiotic resistance analysis.

Mejia, A. I. and G. E. Moglen (2009). "Spatial Patterns of Urban Development from Optimization of Flood Peaks and Imperviousness-Based Measures." Journal of Hydrologic Engineering **14**: 416-424.

Melles, S., S. Glenn, et al. (2003). "Urban Bird Diversity and Landscape Complexity: Species–environment Associations Along a Multiscale Habitat Gradient." Conservation Ecology **7**(1).

For birds in urban environments, the configuration of local habitat within the landscape may be as critical as the composition of the local habitat itself. We examined the relative importance of environmental attributes (e.g., tree cover, composition, and number of tree species) measured at different spatial scales in relation to urban bird species richness and abundance. We expected that some bird species and nesting guilds would have a closer association with landscape-level features (within 1000 m), such as proximity to large forested areas, than with local-scale habitat measures (within 50 m). To investigate this, avian community data were collected at 285 point-count stations in 1997 and 1998 along four roadside transects located in Vancouver and Burnaby, British Columbia, Canada. Transects (5–25 km in length) bisected three large parks (>324 ha) and proceeded along residential streets in urban and suburban areas. In total, 48 bird species were observed, including 25 common species. Species richness declined in relation to a gradient of increasing urbanization, as measured by local- and landscape-level habitat features. We further examined the significance and importance of local- vs. landscape-level habitat attributes using logistic regression and found that both scales explained the presence/absence distributions of residential birds. Local-scale habitat features such as large

coniferous trees, berry-producing shrubs, and freshwater streams were of particular importance in estimating the likelihood of finding bird species. Landscape measures, particularly forest cover (within 500 m) and park area (measured at different scales as a function of distance from point-count stations) significantly improved likelihood estimations based solely on local-scale habitat features. Our results suggest that both local- and landscape-scale resources were important in determining the distribution of birds in urban areas. Parks, reserves, and the surrounding residential areas should be integrated into urban planning and development designs to maintain resident avifauna and overall species diversity in urban environments

Metropolitan, C. (2001). Minnesota Urban Small Sites BMP Manual.

Mitsch, W. J. and J. G. Gosselink (2000). "The value of wetlands: importance of scale and landscape setting." Ecological Economics **35**(1): 25-33.

Wetlands have value because their functions have proved to be useful to humans. The unit value for some wetlands also increases with human development (agriculture and urban) because of increased use and/or increased scarcity. Yet, paradoxically, its functions can easily be overwhelmed in areas of heavy human development, thus lessening those values. Thus wetlands appear to work best in the landscape as spatially distributed systems. Also, the value is partially dependent on where they are found in the landscape, e.g., the degree to which a wetland is open to hydrologic and biological fluxes with other systems, including urban and agricultural landscapes. A paradox of assigning values to wetlands and other ecosystems is that it can argue for the replacement of one system with another if a landscape view is not taken. Estimates of percent of landscape for various functions, e.g. water quality or flood control, are presented. It is suggested that a range of 3–7% of temperate-zone watersheds should be in wetlands to provide adequate flood control and water quality values for the landscape.

Moore, A. A. and M. A. Palmer (2005). "Invertebrate biodiversity in agricultural and urban headwater streams: Implications for conservation and management." Ecological Applications **15**: 1169-1177.

Morgan, R. P. and S. E. Cushman (2005). "Urbanization effects on stream fish assemblages in Maryland, USA." Journal of the North American Benthological Society **24**: 643-655.

Morikawa, H., A. Higaki, et al. (1998). "More than a 600-fold variation in nitrogen dioxide assimilation among 217 plant taxa." Plant, Cell & Environment **21**(2): 180-190.

Assimilation of nitrogen dioxide in response to fumigation with 15N-labelled nitrogen dioxide was studied in 217 plant taxa. The taxa included 50 wild herbaceous plants collected from roadsides (42 genera, 15 families), 60 cultivated herbaceous plants (55 genera, 30 families) and 107 cultivated woody plants (74 genera, 45 families). Two parameters, the 'NO2-N content', or NO2-derived

reduced nitrogen content in fumigated plant leaves (mg N g–1 dry weight), and the 'NO2-utilization index', or percentage of the NO2-derived reduced nitrogen in the total reduced nitrogen, were determined. The NO2-N content differed 657-fold between the highest (Eucalyptus viminalis; 6·57) and lowest (Tillandsia ionantha and T. caput-medusae; 0·01) values in the 217 taxa; 62-fold in a family (Theaceae) and 26-fold in a species (Solidago altissima). Nine species had NO2-utilization indices greater than 10%, of which Magnolia kobus, Eucalyptus viminalis, Populus nigra, Nicotiana tabacum and Erechtites hieracifolia had NO2-N contents > 4·9. These plants can be considered 'NO2-philic' because in them NO2-nitrogen has an important function(s). The Compositae and Myrtaceae had high values for both parameters, whereas the monocots and gymnosperms had low ones. These findings suggest that the metabolic pathway of NO2-nitrogen differs among plant species. The information presented here will be useful for creating a novel vegetation technology to reduce the atmospheric concentration of nitrogen dioxide.

Mpca (2008). What triggers an nondegradation review of potential impacts to high-quality waters? St. Paul, MN, Minnesota Pollution Control Agency.

Murray, B., A. Jenkins, et al. (2009). Valuing Ecosystem Services from Wetlands Restoration in the Mississippi Alluvial Valley, Nicholas Institute for Environmental Policy Studies, Nicholas Institute for the Environment, Duke University**:** 43pp-43pp.

Under appropriate conditions, restoring wetlands on crop fields can result in a net increase of ecosystem services and therefore a net benefit to society. This study assesses the value of actions to restore wetlands via the Wetland Reserve Program (WRP) in the Mississippi Alluvial Valley (MAV) of the U.S. by quantifying and monetizing ecosystem services. Focusing on hardwood bottomland forest, a dominant wetland type of the MAV, in situ measurements of multiple ecosystem services are made on a land use continuum of agricultural land, wetlands restored via WRP, and mature bottomland forest. A subset of these services, namely greenhouse gas (GHG) mitigation, nutrient mitigation, and waterfowl recreation, are selected to be monetized with benefit transfer methods. Above- and belowground carbon estimates and changes in methane (CH4) and nitrous oxide (N2O) emissions are utilized to project GHG flows on the land. Denitrification potential and forgone agriculture-related losses are summed to estimate the amount of nitrogen prevented from entering water bodies. Increased Duck Energy Days (DEDs) on the landscape represent the WRP-induced expansion of waterfowl habitat. We adjust and transform these measures into per-hectare, valuation-ready units and then monetize them with prices from emerging markets (GHG) and environmental economic literature (GHG, nutrient, recreation). Valuing all services produced by wetland restoration would yield the total ecosystem value of the change; however, due to data and model limitations we generate a partial estimate by monetizing three ecosystem services. Social welfare value is found to be between $1,446 and $1,497 per hectare per year, with GHG mitigation valued in the range of $162 to $213, nitrogen mitigation at $1,268, and

waterfowl recreation at $16 per hectare. Limited to existing markets, the estimate for annual market value is merely $74 per hectare, but when fully accounting for potential markets, this estimate rises to $1,068 per hectare. The estimated social value surpasses the one-time public expenditure or social cost of wetlands restoration ($2,526 per hectare) in the MAV in only two years, indicating that the ecosystem service value return on public investment appears to be very attractive in the case of the WRP. Moreover, the finding that annual potential market value is substantially greater than landowner opportunity costs ($401–$411 per hectare) indicates that payments to private landowners to restore wetlands could be profitable for individual landowners in addition to being value-enhancing to society. This should help to motivate the development of ecosystem markets to more fully integrate societal values into land use decisions.

Nassauer, J. I., S. E. Kosek, et al. (2001). "MEETING PUBLIC EXPECTATIONS WITH ECOLOGICAL INNOVATION IN RIPARIAN LANDSCAPES." Journal of the American Water Resources Association **37**(6): 1439-1443.

Appearances matter for managing riparian landscapes because the appearance of landscapes affects public willingness to accept plans and designs that improve ecological quality. Riparian landscape design and planning should respect and strategically incorporate characteristics that the public values and expects to see. Such design can be quite novel in its ecological effects, but it also should be sufficiently familiar in appearance to correspond with cultural values. This paper describes some influential cultural values for riparian landscapes and demonstrates how attention to such values supports public acceptance of ecologically innovative design in rural and urban watersheds.

Novotney, V. and G. Chesters (1981). Handbook of Nonpoint Pollution: Sources and Management. New York, Van Nostrand Reinhold Co.

Until recently, almost all pollution control efforts focused on reduction of pollution from point sources such as municipal sewage and industrial wastewater. Extensive research has revealed, however, that major problems are caused by nonpoint pollutants - those originating from aerial diffuse sources that are mostly related to man 's use of land. Sources and magnitudes of nonpoint pollution, major causative factors, and disturbing activities on land that lead to elevated pollution loadings from diffuse sources are described. Related topics discussed in detail include erosion, hydrologic factors, atmospheric deposition and acid rain, soil degradation and absorption of pollutants, groundwater pollution, urban nonpoint pollution and its mitigation, nonurban pollution and soil conservation practices, modeling techniques, management practices for control of nonpoint pollution, and long-range planning for nonpoint pollution control.

Nowak, D. J. and D. E. Crane The Urban Forest Effects (UFORE) model: quantifying urban forest structure and functions. St. Paul, MN, U.S. Dept. of Agriculture, Forest Service, North Central Forest Experiment Station. **Gen. Tech. Rep. NC-212:** 714-720.

The Urban Forest Effects (UFORE) computer model was developed to help managers and researchers quantify urban forest structure and functions. The model quantifies species composition and diversity, diameter distribution, tree density and health, leaf area, leaf biomass, and other structural characteristics; hourly volatile organic compound emissions (emissions that contribute to ozone formation) throughout a year; total carbon stored and net carbon sequestered annually; and hourly pollution removal by the urban forest and associated percent improvement in air quality throughout a year.

Nowak, D. J. and D. E. Crane (2002). "Carbon storage and sequestration by urban trees in the USA." Environmental Pollution **116**(3): 381-389.

Based on field data from 10 USA cities and national urban tree cover data, it is estimated that urban trees in the coterminous USA currently store 700 million tonnes of carbon ($14,300 million value) with a gross carbon sequestration rate of 22.8 million tC/yr ($460 million/year). Carbon storage within cities ranges from 1.2 million tC in New York, NY, to 19,300 tC in Jersey City, NJ. Regions with the greatest proportion of urban land are the Northeast (8.5%) and the southeast (7.1%). Urban forests in the north central, northeast, south central and southeast regions of the USA store and sequester the most carbon, with average carbon storage per hectare greatest in southeast, north central, northeast and Pacific northwest regions, respectively. The national average urban forest carbon storage density is 25.1 tC/ha, compared with 53.5 tC/ha in forest stands. These data can be used to help assess the actual and potential role of urban forests in reducing atmospheric carbon dioxide, a dominant greenhouse gas.

Nowak, D. J. and D. E. Crane (2006). "Air pollution removal by urban trees and shrubs in the United States." Urban Forestry & Urban Greening **4**(3-4): 115-123.

A modeling study using hourly meteorological and pollution concentration data from across the coterminous United States demonstrates that urban trees remove large amounts of air pollution that consequently improve urban air quality. Pollution removal (O3, PM10, NO2, SO2, CO) varied among cities with total annual air pollution removal by US urban trees estimated at 711,000 metric tons ($3.8 billion value). Pollution removal is only one of various ways that urban trees affect air quality. Integrated studies of tree effects on air pollution reveal that management of urban tree canopy cover could be a viable strategy to improve air quality and help meet clean air standards.

Nowak, D. J., R. E. Hoehn, III, et al. (2010). Assessing urban forest effects and values, Chicago's urban forest. Newtown Square, PA, U.S. Department of Agriculture, Forest Service, Northern Research Station.**:** 27pp-27pp.

An analysis of trees in Chicago, IL, reveals that this city has about 3,585,000 trees with canopies that cover 17.2 percent of the area. The most common tree species are white ash, mulberry species, green ash, and tree-of-heaven. Chicago's urban forest currently stores about 716,000 tons of carbon valued at $14.8 million. In addition, these trees remove about 25,200 tons of carbon per year ($521,000 per

year) and about 888 tons of air pollution per year ($6.4 million per year). Trees in Chicago are estimated to reduce annual residential energy costs by $360,000 per year. The structural, or compensatory, value is estimated at $2.3 billion. Information on the structure and functions of the urban forest can be used to inform urban forest management programs and to integrate urban forests within plans to improve environmental quality in the Chicago area.

Nowak, D. J., R. E. Hoehn, III, et al. (2006). Assessing urban forest effects and values, Washington, D.C.'s urban forest. Newtown Square, PA, U.S. Department of Agriculture, Forest Service, Northern Research Station.**:** 24pp-24pp.

An analysis of trees in Washington, D.C. reveals that this city has about 1,928,000 trees with canopies that cover 28.6 percent of the area. The most common tree species are American beech, red maple, and boxelder. The urban forest currently store about 526,000 tons of carbon valued at $9.7 million. In addition, these trees remove about 16,200 tons of carbon per year ($299,000 per year) and about 540 tons of air pollution per year ($2.5 million per year). The structural, or compensatory, value is estimated at $3.6 billion. Information on the structure and functions of the urban forest can be used to improve and augment support for urban forest management programs and to integrate urban forests within plans to improve environmental quality in the Washington, D.C. area

O'Driscoll, M. A., J. R. Soban, et al. (2009). "STREAM CHANNEL ENLARGEMENT RESPONSE TO URBAN LAND COVER IN SMALL COASTAL PLAIN WATERSHEDS, NORTH CAROLINA." Physical Geography **30**: 528-555.

Owens, P. N., R. J. Batalla, et al. (2005). "Fine-grained sediment in river systems: environmental significance and management issues." River Research and Applications **21**: 693-717.

Paul, M. J. and J. L. Meyer (2001). "Streams in the urban landscape." Annual Review of Ecology and Systematics **32**: 333-365.

Peters, N. E. (2009). "Effects of urbanization on stream water quality in the city of Atlanta, Georgia, USA." Hydrological Processes **23**: 2860-2878.

Phillips, R. A., J. C. Clausen, et al. (2003). "BMP research in a low-impact development environment: the Jordan Cove project." Stormwater **4**(1): 32-38.

Pielke, R. A., A. Beltran-Przekurat, et al. (2006). Impacts of regional land use and land cover on rainfall: an overview, IAHS Publ.

Pitt, R., R. Field, et al. (1995). "URBAN STORMWATER TOXIC POLLUTANTS - ASSESSMENT, SOURCES, AND TREATABILITY." Water Environment Research **67**: 260-275.

Pizzuto, J. E., W. C. Hession, et al. (2000). "Comparing gravel-bed rivers in paired urban and rural catchments of southeastern Pennsylvania." Geology **28**(1): 79-82.

Surveys in eight paired urban and rural watersheds illustrate how urbanization changes fluvial morphology and processes. Our data also provide quantitative criteria for evaluating stream-restoration projects in urban areas. Bankfull depth, reach-averaged bed slope, and median grain size are similar in urban and rural watersheds. The median width of urban channels is 26% larger than the median width of rural channels. The median sinuosity is 8% lower in urban channels and pools are 31% shallower. The median composite Manning's n based on median grain diameter, pool depth, and channel sinuosity is 10% lower in urban streams, while the median bankfull discharge per unit drainage basin area is 131% higher in urban channels. Histograms of bed sediment-size distributions in urban channels lack a secondary mode in the size range 2-64 mm characteristic of rural channels, indicating that these sizes tend to be selectively removed from urban channels. However, bankfull Shields stresses in urban and rural channels exceed typical threshold values at most sites, indicating significant bedload transport at bankfull stage. Apparently, increased peak discharges caused by decades of urbanization have not removed all the transportable sediment from these urban stream channels. We speculate that the supply of sediment to urban channels from hillslope processes and channel erosion remains significant, even though much of the upland surfaces of these urban catchments are covered with nonerodible impervious surfaces.

Poff, N. L., B. P. Bledsoe, et al. (2006). "Hydrologic variation with land use across the contiguous United States: Geomorphic and ecological consequences for stream ecosystems." Geomorphology **79**: 264-285.

Poff, N. L., B. D. Richter, et al. (2010). "The ecological limits of hydrologic alteration (ELOHA): a new framework for developing regional environmental flow standards." Freshwater Biology **55**: 147-170.

Pouyat, R., P. Groffman, et al. (2002). "Soil carbon pools and fluxes in urban ecosystems." Environmental Pollution **116**(Supplement 1): S107-S118-S107-S118.

The transformation of landscapes from non-urban to urban land use has the potential to greatly modify soil carbon (C) pools and fluxes. For urban ecosystems, very little data exists to assess whether urbanization leads to an increase or decrease in soil C pools. We analyzed three data sets to assess the potential for urbanization to affect soil organic C. These included surface (0–10 cm) soil C data from unmanaged forests along an urban–rural gradient, data from “made” soils (1 m depth) from five different cities, and surface (0–15 cm) soil data of several land-use types in the city of Baltimore. Along the urban–rural land-use gradient, we found that soil organic matter concentration in the surface 10 cm varied significantly (P=0.001). In an analysis of variance, the urban forest stands had significantly (P=0.02) higher organic C densities (kg m−2 to 1 m depth) than the suburban and rural stands. Our analysis of pedon data from five

cities showed that the highest soil organic C densities occurred in loamy fill (28.5 kg m−2) with the lowest occurring in clean fill and old dredge materials (1.4 and 6.9 kg m−2, respectively). Soil organic C densities for residential areas (15.5±1.2 kg m−2) were consistent across cities. A comparison of land-use types showed that low density residential and institutional land-uses had 44 and 38% higher organic C densities than the commercial land-use type, respectively. Our analysis shows that as adjacent land-use becomes more urbanized, forest soil C pools can be affected even in stands not directly disturbed by urban land development. Data from several "made" soils suggests that physical disturbances and inputs of various materials by humans can greatly alter the amount C stored in these soils.

Pouyat, R. V., I. D. Yesilonis, et al. (2009). "A comparison of soil organic carbon stocks between residential turf grass and native soil." Urban Ecosystems **12**(1): 45-62.

A central principle in urban ecological theory implies that in urbanized landscapes anthropogenic drivers will dominate natural drivers in the control of soil organic carbon storage (SOC). To assess the effect of urban land-use change on the storage of SOC, we compared SOC stocks of turf grass and native cover types of two metropolitan areas (Baltimore, MD, and Denver, CO) representing climatologically distinct regions in the United States. We hypothesized that introducing turf grass and management will lead to higher SOC densities in the arid Denver area and lower densities in the mesic Baltimore area relative to native cover types. Moreover, differences between turf grass soils will be less than differences between the native soils of each metropolitan region. Within Baltimore, turf grass had almost a 2-fold higher SOC density at 0- to 1-m and 0- to 20-cm depths than in rural forest soils, whereas there were no differences with soils of urban forest remnants. Moreover, urban forest remnants had more than 70% higher SOC densities than rural forest soils. Within Denver, turf grass (>25 years of age) had more than 2-fold higher SOC densities than in shortgrass steppe soils, while having similar densities to Baltimore turf grass soils. By contrast, the native soils of Baltimore were almost 2-fold higher than the native steppe grass soils of Denver using SOC densities of remnant forests as representative of native soils in the Baltimore region. These results supported our hypothesis that turf grass systems will be similar in SOC densities across regional variations in climate, parent material, and topography. These similarities are apparently due to greater management efforts in the Denver region to offset the constraint of climate, i.e., anthropogenic factors (management supplements) overwhelmed native environmental factors that control SOC storage.

Pouyat, R. V., I. D. Yesilonis, et al. (2006). "Carbon Storage by Urban Soils in the United States." J Environ Qual **35**: 1566-1575.

We used data available from the literature and measurements from Baltimore, Maryland, to (i) assess inter-city variability of soil organic carbon (SOC) pools (1-m depth) of six cities (Atlanta, Baltimore, Boston, Chicago, Oakland, and Syracuse); (ii) calculate the net effect of urban land-use conversion on SOC pools for the same cities; (iii) use the National Land Cover Database to extrapolate total

SOC pools for each of the lower 48 U.S. states; and (iv) compare these totals with aboveground totals of carbon storage by trees. Residential soils in Baltimore had SOC densities that were approximately 20 to 34% less than Moscow or Chicago. By contrast, park soils in Baltimore had more than double the SOC density of Hong Kong. Of the six cities, Atlanta and Chicago had the highest and lowest SOC densities per total area, respectively (7.83 and 5.49 kg m–2). On a pervious area basis, the SOC densities increased between 8.32 (Oakland) and 10.82 (Atlanta) kg m–2. In the northeastern United States, Boston and Syracuse had 1.6-fold less SOC post- than in pre-urban development stage. By contrast, cities located in warmer and/or drier climates had slightly higher SOC pools post- than in pre-urban development stage (4 and 6% for Oakland and Chicago, respectively). For the state analysis, aboveground estimates of C density varied from a low of 0.3 (WY) to a high of 5.1 (GA) kg m–2, while belowground estimates varied from 4.6 (NV) to 12.7 (NH) kg m–2. The ratio of aboveground to belowground estimates of C storage varied widely with an overall ratio of 2.8. Our results suggest that urban soils have the potential to sequester large amounts of SOC, especially in residential areas where management inputs and the lack of annual soil disturbances create conditions for net increases in SOC. In addition, our analysis suggests the importance of regional variations of land-use and land-cover distributions, especially wetlands, in estimating urban SOC pools.

Praskievicz, S. and H. J. Chang (2009). "A review of hydrological modelling of basin-scale climate change and urban development impacts." Progress in Physical Geography **33**: 650-671.

Randhir, T. O. and A. G. Hawes (2009). "Watershed land use and aquatic ecosystem response: Ecohydrologic approach to conservation policy." Journal of Hydrology **364**: 182-199.

Renwick, W. H. (2006). Small Artificial Ponds in the United States: Impacts on Sedimentation and Carbon Budget, Reno, NV.

Richardson, E. V. and F. W. Huber (1991). "EVALUATION OF BRIDGE VULNERABILITY TO HYDRAULIC FORCES, STREAM INSTABILITY, AND SCOUR." Transportation Research Board(1290): 25-38.

Riley, S. P. D., G. T. Busteed, et al. (2005). "Effects of urbanization on the distribution and abundance of amphibians and invasive species in southern California streams." Conservation Biology **19**: 1894-1907.

Rose, S. and N. E. Peters (2001). "Effects of urbanization on streamflow in the Atlanta area (Georgia, USA): a comparative hydrological approach." Hydrological Processes **15**: 1441-1457.

Rosenfeld, A. H. and J. J. Romm (1996). POLICIES TO REDUCE HEAT ISLANDS: MAGNITUDES OF BENEFITS AND INCENTIVES TO ACHIEVE THEM1, Pacific Grove, CA.

A "Cool Communities" strategy of lighter-colored reroofs and resurfaced pavements, and shade trees, can directly lower annual air conditioning bills in Los Angeles (LA) by about $100 million (M), cool the air in the LA Basin (thereby saving indirectly $70M more in air conditioning), and reduce smog exceedance by about 10%, worth another $360M, for a total savings of about $0.5 billion per year. Trees are most effective if they shade buildings; but they are still very cost effective if they merely cool the air by evapotranspiration. Avoided peak power for air conditioning can be about 1.5GW (more than 15% of LA air conditioning). Extrapolated to the entire United States, we estimate 20GW avoided and potential annual electricity savings of about $5-10B in 2015. To achieve these savings, we call for ratings and labels for cool materials, buildings' performance standards, utility incentive programs, and an extension of the existing smog-offset trading market ("RECLAIM") to include credit for cool surfaces and trees. EPA can include cool materials and trees in its proposed regional "open market smog-offset trading credits".

Roy, A. H., B. J. Freeman, et al. (2007). "Riparian influences on stream fish assemblage structure in urbanizing streams." Landscape Ecology **22**: 385-402.

Roy, A. H., M. C. Freeman, et al. (2005). "Investigating hydrologic alteration as a mechanism of fish assemblage shifts in urbanizing streams." Journal of the North American Benthological Society **24**: 656-678.

Roy, A. H., M. C. Freeman, et al. (2006). "Importance of riparian forests in urban catchments contingent on sediment and hydrologic regimes." Environmental Management **37**: 523-539.

Roy, A. H., A. D. Rosemond, et al. (2003). "Stream macroinvertebrate response to catchment urbanisation (Georgia, U.S.A.)." Freshwater Biology **48**(2): 329-346.

1. The effects of catchment urbanisation on water quality were examined for 30 streams (stratified into 15, 50 and 100 $km^2 \pm 25\%$ catchments) in the Etowah River basin, Georgia, U.S.A. We examined relationships between land cover <link rid="q1"> (implying cover and use) in these catchments (e.g. urban, forest and agriculture) and macroinvertebrate assemblage attributes using several previously published indices to summarise macroinvertebrate response. Based on a priori predictions as to mechanisms of biotic impairment under changing land cover, additional measurements were made to assess geomorphology, hydrology and chemistry in each stream. 2. We found strong relationships between catchment land cover and stream biota. Taxon richness and other biotic indices that reflected good water quality were negatively related to urban land cover and positively related to forest land cover. Urban land cover alone explained 29-38% of the variation in some macroinvertebrate indices. Reduced water quality was

detectable at c. >15% urban land cover. 3. Urban land cover correlated with a number of geomorphic variables such as stream bed sediment size (-) and total suspended solids (+) as well as a number of water chemistry variables including nitrogen and phosphorus concentrations (+), specific conductance (+) and turbidity (+). Biotic indices were better predicted by these reach scale variables than single, catchment scale land cover variables. Multiple regression models explained 69% of variation in total taxon richness and 78% of the variation in the Invertebrate Community Index (ICI) using phi variability, specific conductance and depth, and riffle phi, specific conductance and phi variability, respectively. 4. Indirect ordination analysis was used to describe assemblage and functional group changes among sites and corroborate which environmental variables were most important in driving differences in macroinvertebrate assemblages. The first axis in a non-metric multidimensional scaling ordination was highly related to environmental variables (slope, specific conductance, phi variability; adj. R2=0.83) that were also important in our multiple regression models. 5. Catchment urbanisation resulted in less diverse and more tolerant stream macroinvertebrate assemblages via increased sediment transport, reduced stream bed sediment size and increased solutes. The biotic indices that were most sensitive to environmental variation were taxon richness, EPT richness and the ICI. Our results were largely consistent over the range in basin size we tested.

Sailor, D. J. and N. Dietsch (2007). "The urban heat island Mitigation Impact Screening Tool (MIST)." Environmental Modelling & Software **22**(10): 1529-1541.

A web-based software tool has been developed to assist urban planners and air quality management officials in assessing the potential of urban heat island mitigation strategies to affect the urban climate, air quality, and energy consumption within their cities. The user of the tool can select from over 170 US cities for which to conduct the analysis, and can specify city-wide changes in surface reflectivity and/or vegetative cover. The Mitigation Impact Screening Tool (MIST) then extrapolates results from a suite of simulations for 20 cities to estimate air temperature changes associated with the specified changes in surface characteristics for the selected city. Alternatively the user can simply define a nominal air temperature reduction that they hope to achieve with an unspecified mitigation scenario. These air temperature changes are then input to energy and ozone models to estimate the impact that the mitigation action may have on the selected city. The results presented by MIST include a high degree of uncertainty and are intended only as a first-order estimate that urban planners can use to assess the viability of heat island mitigation strategies for their cities. As appropriate, MIST analyses should be supplemented by more detailed modeling.

San Francisco Bay Regional Water Resources Control, B. (2007). Beneficial Uses.

Sandahl, J. F., D. H. Baldwin, et al. (2007). "A sensory system at the interface between urban stormwater runoff and salmon survival." Environmental Science & Technology **41**: 2998-3004.

Sansalone, J. J., J. M. Koran, et al. (1998). "Physical characteristics of urban roadway solids transported during rain events." Journal of Environmental Engineering-Asce **124**: 427-440.

Santo Domingo, J. Fecal Source Tracking: Past, Present & Future.

Schiff, R. and G. Benoit (2007). "Effects of impervious cover at multiple spatial scales on coastal watershed streams." Journal of the American Water Resources Association **43**: 712-730.

Schoonover, J. E. and B. G. Lockaby (2006). "Land cover impacts on stream nutrients and fecal coliform in the lower Piedmont of West Georgia." Journal of Hydrology **331**: 371-382.

Schueler, T. R., L. Fraley-McNeal, et al. (2009). "Is Impervious Cover Still Important? Review of Recent Research." Journal of Hydrologic Engineering **14**: 309-315.

Schwecke, M., B. Simmons, et al. (2007). "Sustainable use of stormwater for irrigation case study: Manly Golf Course." The Environmentalist **27**(1): 51-61.

Seigel, A., C. Hatfield, et al. "Avian Response to Restoration of Urban Tidal Marshes in the Hackensack Meadowlands, New Jersey." Urban Habitats **3**(1): online-online.

Tidal marshes located in urbanized regions have experienced a long history of degradation. As a result, restorations have frequently been conducted to improve the habitat quality of these marshes. Few studies, however, have investigated the effect of restoration on avian community composition in urban tidal marshes. To this end, we conducted avian surveys for one year prior to restoration and three years after restoration at Harrier Meadow marsh, in the Hackensack Meadowlands, New Jersey. After restoration, avian species richness and abundance increased, while evenness decreased, mostly due to large flocks of sandpipers sporadically visiting the marsh during migration. Prior to restoration, generalists were by far the most abundant foraging guild, while they shared dominance with mudflat and open-water foragers after restoration. Avian surveys were also conducted for three years after restoration at Mill Creek marsh, also in the Meadowlands. Though the restoration goals were the same for Harrier Meadow and Mill Creek, the two marshes had distinct habitat compositions after restoration, and this allowed us to examine avian response to variation in habitat availability. In all three years of monitoring after restoration, Harrier had a greater avian density and higher species richness than Mill Creek; however, avian abundance at both marshes was dominated by the same three foraging guilds. Evenness did not differ across post-restoration years or between marshes. Avian abundance showed a decreasing trend during the three years of post-restoration monitoring; however, further monitoring will be necessary to determine the long-term trends in the avian community.

Selbig, W. R. and R. T. Bannerman (2008). "A comparison of runoff quantity and quality from two small basins undergoing implementation of conventional-and low-impact-development (LID) strategies: Cross Plains, Wisconsin, water years 1999–2005." US Geological Survey Scientific Investigations Report **5008**: 57-57.

Environmental managers are often faced with the task of designing strategies to accommodate development while minimizing adverse environmental impacts. Low-impact development (LID) is one such strategy that attempts to mitigate environmental degradation commonly associated with impervious surfaces. The U.S. Geological Survey, in cooperation with the Wisconsin Department of Natural Resources, studied two residential basins in Cross Plains, Wis., during water years 1999–2005. A paired-basin study design was used to compare runoff quantity and quality from the two basins, one of which was developed in a conventional way and the other was developed with LID. The conventional-developed basin (herein called “conventional basin”) consisted of curb and gutter, 40-foot street widths, and a fully connected stormwater-conveyance system. The LID basin consisted of grassed swales, reduced impervious area (32-foot street widths), street inlets draining to grass swales, a detention pond, and an infiltration basin. Data collected in the LID basin represented predevelopment through near-complete build-out conditions. Smaller, more frequent precipitation events that produced stormwater discharge from the conventional basin were retained in the LID basin. Only six events with precipitation depths less than or equal to 0.4 inch produced measurable discharge from the LID basin. Of these six events, five occurred during winter months when underlying soils are commonly frozen, and one was likely a result of saturated soil from a preceding storm. In the conventional basin, the number of discharge events, using 1 U.S. Geological Survey, Middleton, Wisconsin 2 Wisconsin Department of Natural Resources, Madison, Wisconsin the same threshold of precipitation depth, was 180, with nearly one-half of those resulting from precipitation depths less than 0.2 inch. Precipitation events capable of producing appreciable discharge in the LID basin were typically those of high intensity or precipitation depth or those that occurred after soils were already saturated. Total annual discharge volume measured from the conventional basin ranged from 1.3 to 9.2 times that from the LID basin. Development of the LID basin did not appreciably alter the hydrologic response to precipitation characterized during predevelopment conditions. Ninety-five percent or more of precipitation in the LID basin was retained during each year of construction from predevelopment through near-complete build-out, surpassing the 90-percent benchmark established for new development by the Wisconsin Department of Natural Resources. The amount of precipitation retained in the conventional basin did not exceed 94 percent and fell below the 90-percent standard 2 of the 6 years monitored. Much of the runoff in the LID basin was retained by an infiltration basin, the largest control structure used to mitigate storm-runoff quantity and quality. The infiltration basin also was the last best-management practice (BMP) used to treat runoff before it left the LID basin as discharge. From May 25, 2002, to September 30, 2005, only 24 of 155

precipitation events exceeded the retention/ infiltrative capacity of the infiltration basin. The overall reduction in runoff volume from these few events was 51 percent. The effectiveness of the infiltration basin decreased as precipitation intensities exceeded 0.5 inch per hour.

Seurinck, S., W. Verstraete, et al. (2005). "Microbial Source Tracking for Identification of Fecal Pollution." Reviews in Environmental Science and Biotechnology **4**(1): 19-37.

Fecal pollution is a serious environmental problem that affects many coastal and inland waters worldwide. Both human and animal fecal pollution impose risks to human health from exposure to pathogenic bacteria, viruses, and protozoa. To assist authorities with the implementation of the changes suggested by more restricted legislation concering water quality in Europe, methods are needed which can identify the sources of fecal pollution. Management of fecal contamination of water would be improved if the origin of the fecal pollution could be correctly identified since remediation efforts could then be allocated in a more effective manner. The concept that the origin of fecal pollution can be traced has been termed microbial source tracking. In microbial source tracking (MST) endogenous markers of fecal sources are used for identification of the fecal pollution in aquatic environments. Chemical MST-methods can be used to trace mainly sewage pollution, but the used chemical targets have no direct relationship with pathogenic bacteria. This is not the case in microbial MST-methods where source-specific bacteria or viruses are cultured to identify fecal pollution sources. However, sometimes these microbial targets can be present in too low numbers to be detected. This is circumvented by using molecular assays for host-specific marker detection. Phenotypic and genotypic library-based methods can be used to discriminate among different fecal sources. However, the isolation step makes this procedure very labour-intensive, and issues as temporal and geographical variability remain unresolved. The underlying assumptions will be discussed and the methods mostly used in microbial source tracking will be described in more detail.

Seurinck, S., W. Verstraete, et al. (2005). "Microbial Source Tracking for Identification of Fecal Pollution." Reviews in Environmental Science and Bio/Technology **4**(1-2): 19-37.

Shepherd, J. M. (2005). "A Review of Current Investigations of Urban-Induced Rainfall and Recommendations for the Future." Earth Interactions **9**(12): 1-27.

Precipitation is a key link in the global water cycle and a proxy for changing climate; therefore, proper assessment of the urban environment’s impact on precipitation (land use, aerosols, thermal properties) will be increasingly important in ongoing climate diagnostics and prediction, Global Water and Energy Cycle (GWEC) analysis and modeling, weather forecasting, freshwater resource management, urban planning–design, and land–atmosphere–ocean interface processes. These facts are particularly critical if current projections for global urban growth are accurate.The goal of this paper is to provide a concise

review of recent (1990–present) studies related to how the urban environment affects precipitation. In addition to providing a synopsis of current work, recent findings are placed in context with historical investigations such as Metropolitan Meteorological Experiment (METROMEX) studies. Both observational and modeling studies of urban-induced rainfall are discussed. Additionally, a discussion of the relative roles of urban dynamic and microphysical (e.g., aerosol) processes is presented. The paper closes with a set of recommendations for what observations and capabilities are needed in the future to advance our understanding of the processes.

Shrestha, R. K. and J. R. R. Alavalapati (2004). "Effect of Ranchland Attributes on Recreational Hunting in Florida: A Hedonic Price Analysis." Journal of Agricultural and Applied Economics **36**(3): 763-772.

Recreational hunting has been an attractive enterprise for some ranchers who are interested in supplementing their income from cattle. Ranchland attributes-such as parcel size, tree cover, and proximity to urban centers-are expected to influence hunters preferences and, thus, hunting lease payments. We estimated the effects of these attributes on hunting revenues using a hedonic model. The results reveal that trees and vegetation cover on ranchlands have a positive impact on hunting revenues, indicating opportunities for silvopasture practices. Those ranchers in Florida who maintain about 22% trees and other vegetation cover receive $16.15 acre per year from hunting leases, but doubling the cover would generate only an additional $3.20 per acre per year.

Shukla, S. and F. Jaber (2006). Stormwater as an Alternative Source of Water Supply: Feasibility and Implications for Watershed Management. Florida Cooperative Extension circular. **#CIR1493**.

Simpson, J. M., J. W. Santo Domingo, et al. (2002). "Microbial source tracking: state of the science." Environmental Science & Technology **36**(24): 5279-5288.

Although water quality of the Nation's lakes, rivers and streams has been monitored for many decades and especially since the passage of the Clean Water Act in 1972, many still do not meet the Act's goal of "fishable and swimmable". While waterways can be impaired in numerous ways, the protection from pathogenic microbe contamination is most important for waters used for human recreation, drinking water and aquaculture. Typically, monitoring methods used for detecting potential pathogenic microorganisms in environmental waters are based upon cultivation and enumeration of fecal indicator bacteria (i.e. fecal coliforms, E. coli, and fecal enterococci). Currently, there is increasing interest in the potential for molecular fingerprinting methods to be used not only for detection but also for identification of fecal contamination sources. Molecular methods have been applied to study the microbial ecology of environmental systems for years and are now being applied to help improve our waters by identifying problem sources and determining the effect of implemented remedial solutions. Management and remediation of water pollution would be more cost-

effective if the correct sources could be identified. This review provides an outline of the main methods that either have been used or have been suggested for use in microbial source tracking and some of the limitations associated with those methods.

Skm and I. Queensland Water (2008). Review of Urban Stormwater Harvesting.

Smith, J. E., L. S. Heath, et al. (2006). Methods for calculating forest ecosystem and harvested carbon with standard estimates for forest types of the United States. Newtown Square, PA, U.S. Department of Agriculture, Forest Service, Northeastern Research Station**:** 216pp-216pp.

This study presents techniques for calculating average net annual additions to carbon in forests and in forest products. Forest ecosystem carbon yield tables, representing stand-level merchantable volume and carbon pools as a function of stand age, were developed for 51 forest types within 10 regions of the United States. Separate tables were developed for afforestation and reforestation. Because carbon continues to be sequestered in harvested wood, approaches to calculate carbon sequestered in harvested forest products are included. Although these calculations are simple and inexpensive to use, the uncertainty of results obtained by using representative average values may be high relative to other techniques that use site- or project-specific data. The estimates and methods in this report are consistent with guidelines being updated for the U.S. Voluntary Reporting of Greenhouse Gases Program and with guidelines developed by the Intergovernmental Panel on Climate Change. The CD-ROM included with this publication contains a complete set of tables in spreadsheet format.

Smith, R. F. and W. O. Lamp (2008). "Comparison of insect communities between adjacent headwater and main-stem streams in urban and rural watersheds." Journal of the North American Benthological Society **27**: 161-175.

Smith, S. V., W. H. Renwick, et al. (2002). "Distribution and significance of small, artificial water bodies across the United States landscape." The Science of The Total Environment **299**(1-3): 21-36.

At least 2.6 million small, artificial water bodies dot the landscape of the conterminous United States; most are in the eastern half of the country. These features account for approximately 20% of the standing water area across the United States, and their impact on hydrology, sedimentology, geochemistry, and ecology is apparently large in proportion to their area. These features locally elevate evaporation, divert and delay downstream water flow, and modify groundwater interactions. They apparently intercept about as much eroded soil as larger, better-documented reservoirs. Estimated vertical accretion rates are much higher, hence, inferred sedimentary chemical reactions must be different in the small features than in larger ones. Finally, these features substantially alter the characteristics of aquatic habitats across the landscape.

Snodgrass, J. W., M. J. Komoroski, et al. (2000). "Relationships among Isolated Wetland Size, Hydroperiod, and Amphibian Species Richness: Implications for Wetland Regulations." Conservation Biology **14**(2): 414-419.

Wetland development within the United States is regulated primarily by size. Decisions concerning wetland destruction or conservation are therefore based in part on three inherent assumptions: (1) small wetlands contain water for short portions of the year; (2) small wetlands support few species; and (3) species found in small wetlands are also found in larger wetlands. We tested these assumptions using data on wetland size, relative hydroperiod (drying scores), and relative species richness of amphibians in depression wetlands of the southeastern United States. We found a significant ($p = 0.03$) but weak ($r2 = 0.05$) relationship between hydroperiod and wetland size and no relationship ($p = 0.48$) between amphibian species richness and wetland size. Furthermore, synthetic models of lentic communities predict that short-hydroperiod wetlands support a unique group of species. Empirical investigations support this prediction. Our results indicate that hydroperiod length should be included as a primary criterion in wetland regulations. We advocate a landscape approach to wetlands regulation, focused in part on conserving a diversity of wetlands that represent the entire hydroperiod gradient.

Solecki, W. D., C. Rosenzweig, et al. (2005). "Mitigation of the heat island effect in urban New Jersey." Global Environmental Change Part B: Environmental Hazards **6**(1): 39-49.

Implementation of urban heat island (UHI) mitigation strategies such as increased vegetative cover and higher-albedo surface materials can reduce the impacts of biophysical hazards in cities, including heat stress related to elevated temperatures, air pollution and associated public health effects. Such strategies also can lower the demand for air-conditioning-related energy production. Since local impacts of global climate change may be intensified in areas with UHIs, mitigation strategies could play an increasingly important role as individuals and communities adapt to climate change. We use CITYgreen, a GIS-based modeling application, to estimate the potential benefits of urban vegetation and reflective roofs as UHI mitigation strategies for case study sites in and around Newark and Camden, New Jersey. The analysis showed that urban vegetation can reduce health hazards associated with the UHI effect by removing pollutants from the air. Less affluent, inner-city neighborhoods are the ones in which the hazard potential of the UHI effect is shown to be greatest. However, these neighborhoods have less available open space for tree planting and therefore a lower maximum potential benefit. As the climate warms, these neighborhoods may face greater consequences due to interactions between the UHI effect and global climate change. Results also show that urban vegetation is an effective and economically efficient way to reduce energy consumption and costs at the sites.

Sparling, D. W., J. D. Eisemann, et al. (2004). "Contaminant Exposure and Effects in Red-Winged Blackbirds Inhabiting Stormwater Retention Ponds." Environmental Management **33**(5): 719-729.

Stormwater wetlands are created to retain water from storms and snow melt to reduce sediment, nutrient, and contaminant pollution of natural waterways in metropolitan areas. However, they are often a source of attractive habitat to wetland-associated wildlife. In this study of 12 stormwater wetlands and a larger, older reference site, elevated concentrations of zinc and copper were found in sediments and carcasses of 8-day-old red-winged blackbird (Agelaius phoeniceus) nestlings inhabiting stormwater sites. Although nesting success in the stormwater wetlands was comparable to national averages, sediment zinc concentrations correlated with clutch size, hatching success, fledgling success, and Mayfield nest success, suggesting that the nestlings may have been stressed and impaired by elevated zinc. This stress may have been direct on the nestlings or indirect through effects on the availability of food organisms.

Spellerberg, I. F. (1998). "Ecological effects of roads and traffic: a literature review." Global Ecology and Biogeography **7**: 317-333.

Stanfield, L. W. and B. W. Kilgour (2006). "Effects of percent impervious cover on fish and benthos assemblages and instream habitats in Lake Ontario tributaries." American Fisheries Society Symposium **48**: 577-599.

We demonstrate the effects of percent impervious cover (PIC) on biophysical properties of Lake Ontario tributary streams. Biophysical data (fish assemblages, benthic invertebrate assemblages (benthos), instream physical habitat, and temperature) were collected from more than 575 wadeable stream sites. A geographic information system application was developed to characterize the landscape upstream of each site (i.e., drainage area, surficial geology, land use/land cover, slope, stream length, and climate). Total PIC of catchments was estimated from land use/land cover, and a base flow index was derived from the surficial geology. The relationship between PIC and biophysical responses was determined after statistically removing the effects of natural landscape features (i.e., catchment area, slope, base flow index) on those responses. Contrasts in PIC from natural conditions (<3% to 10%) were related to variations in fish and benthos assemblages. Both coldwater sensitive and warmwater tolerant fish and diverse benthos assemblages were found in catchments with low PIC. At more than 10 PIC (i.e., about 50% urban), both fish and benthos consisted of mainly warmwater or tolerant assemblages. For example, trout were absent and minnows were dominant. While some of the apparent PIC effect may have been confounded by land use/land cover and surficial geology, the consistency of the findings even after natural catchment conditions were considered suggests that the threshold response is valid. Percent impervious cover had a weaker effect on instream geomorphic variables than on biological variables. The models derived from this study can be used to predict stream biophysical conditions for catchments with varying levels of development.

State of, G. (2008). Georgia Comprehensive State-wide Water Management Plan, State of Georgia.

Stevenson, J. C., L. G. Ward, et al. (1988). "Sediment transport and trapping in marsh systems: Implications of tidal flux studies." Marine Geology **80**(1-2): 37-59.

Although the concept that marshes act as major sediment sinks may be accurate when viewing them over the last few millennia, tidal transport studies suggest considerable variability with most marshes presently exporting material on an annual basis. High-salinity marshes along the mid-Atlantic coast of the United States appear to be losing 1-2 kg m-2 yr-1 while submerged upland marshes on the Delmarva Peninsula are eroding at rates of up to 14 kg m-2 yr-1. By comparison, at least one deltaic marsh on the Dutch coast along with several estuarine marshes appear to be accumulating sediment. In order to assess the trapping ability of marshes in large estuaries, we constructed a sediment budget for Chesapeake Bay which included a variety of wetland types. Calculations indicate that estuarine marshes trap 5-11% of the annual Chesapeake Bay sediment input, or about one half that previously estimated. It appears that most sedimentation in estuaries, and perhaps other coastal systems, occurs in subtidal flats below the limit of emergent marsh vegetation. As mud flats become vegetated and estuarine infilling proceeds, there may be a tendency for tidal currents to become ebb-dominated which promotes a net export of particulates. The extent to which major storm events are capable of returning enough material to balance the long-term accretionary budget of tidal marshes and keep them abreast of rising sea level is open to question. Differences in tidal dynamics, seasonal changes in sea levels and higher temperatures may help explain why, in the U.S., southern marshes are more susceptible to export and eventual erosion than northern marshes. We hypothesize that another factor, the recent reductions of terrigenous sediment inputs from the southern river systems of the U.S., may also be critical. Sediment starvation may have led to undernourishment of wetland systems of the coastal zone over the last half century which may be reflected in the net export measured in the tidal marshes in this region. Furthermore, we postulate that changes in sediment inputs are more important than eustatic sea level rise in causing the past losses of marshes which are now undergoing mass erosion. Thus, future wetland survival will depend as much as particulate inputs to the coastal zone as on the prospects of a global rise in sea level, and more efforts should be made to quantify the sediment budgets of tidal marshes.

Stoeckel, D. M. and V. J. Harwood (2007). "Performance, Design, and Analysis in Microbial Source Tracking Studies." Appl. Environ. Microbiol. **73**(8): 2405-2415.

Stone, B. and J. M. Norman (2006). "Land use planning and surface heat island formation: A parcel-based radiation flux approach." Atmospheric Environment **40**(19): 3561-3573.

This article presents a study of residential parcel design and surface heat island formation in a major metropolitan region of the southeastern United States. Through the integration of high-resolution multispectral data (10 m) with property tax records for over 100,000 single-family residential parcels in the Atlanta, Georgia, metropolitan region, the influence of the size and material composition of residential land use on an indicator of surface heat island formation is reported. In contrast to previous work on the urban heat island, this study derives a parcel-based indicator of surface warming to permit the impact of land use planning regulations governing the density and design of development on the excess surface flux of heat energy to be measured. The results of this study suggest that the contribution of individual land parcels to regional surface heat island formation could be reduced by approximately 40% through the adoption of specific land use planning policies, such as zoning and subdivision regulations, and with no modifications to the size or albedo of the residential structure.

Sutula, M. and E. Stein (2003). Habitat Value of Natural and Constructed Wetlands Used to Treat Urban Runoff: A Literature Review, Southern California Coastal Water Research Program**:** 82pp-82pp.

Swartz, C. H., S. Reddy, et al. (2006). "Steroid Estrogens, Nonylphenol Ethoxylate Metabolites, and Other Wastewater Contaminants in Groundwater Affected by a Residential Septic System on Cape Cod, MA." Environmental Science & Technology **40**(16): 4894-4902.

Septic systems serve approximately 25% of U.S. households and may be an important source of estrogenic and other organic wastewater contaminants (OWC) to groundwater. We monitored several estrogenic OWC, including nonylphenol (NP), nonylphenol mono- and diethoxycarboxylates (NP1EC and NP2EC), the steroid hormones 17β-estradiol (E2), estrone (E1) and their glucuronide and sulfate conjugates, and other OWC such as methylene blue active substances (MBAS), caffeine and its degradation product paraxanthine, and two fluorescent whitening agents in a residential septic system and in downgradient groundwater. E1 and E2 were present predominantly as free estrogens in groundwater, and near-source groundwater concentrations of all OWC were highest in the suboxic to anoxic portion of the wastewater plume, where concentrations of most OWC were similar to those observed in the septic tank on the same day. NP and NP2EC were up to 6- to 30-fold higher, and caffeine and paraxanthine were each 60-fold lower than septic tank concentrations, suggesting net production and removal, respectively, of these constituents. At the most shallow, oxic depth, concentrations of all OWC except for NP2EC were substantially lower than in the tank and in deeper wells. Yet boron, specific conductance, and the sum of nitrate-and ammonia-nitrogen were highest at this shallow depth, suggesting preferential losses of OWC along the more oxic flow lines. As far as 6.0 m downgradient, concentrations of many OWC were within a factor of 2 of near-source concentrations. The results suggest that there is the

potential for migration of these OWC, which are unregulated and not routinely monitored, in groundwater.

Taylor, A. C. and T. D. Fletcher (2007). "Nonstructural urban stormwater quality measures: Building a knowledge base to improve their use." Environmental Management **39**: 663-677.

Taylor, G. D., T. D. Fletcher, et al. (2005). "Nitrogen composition in urban runoff - implications for stormwater management." Water Research **39**: 1982-1989.

Thomas, M. A. (2000). "The effect of residential development on ground-water quality near Detroit, Michigan." Journal of the American Water Resources Association **36**: 1023-1038.

Thompson, A. M., K. Kim, et al. (2008). "Thermal Characteristics of Stormwater Runoff from Asphalt and Sod Surfaces." Journal of the American Water Resources Association **44**: 1325-1336.

Tilghman, N. G. (1987). "Characteristics of urban woodlands affecting breeding bird diversity and abundance." Landscape and Urban Planning **14**: 481-495.

Breeding bird communities were studied in 32 forest islands surrounded by urban development. These isolated woodlands in Springfield, Massachusetts, provided breeding habitats for a wider variety of birds (77 species) than previously described for other urban habitats (e.g. four times as many species as found in urban residential areas in the same city in a previous study). The size of the woodland was the primary influence on bird diversity in these woodlands, explaining 79 and 75% of the variation in total species richness and the Shannon-Weaver index of bird species diversity, respectively. Other woodland characteristics that played a significant role in determining the variety of bird species were the density of buildings in the area immediately adjacent to the woods, density of shrubs within the woods, distance to the nearest trail, distance to the nearest body of water and average canopy height. Percentage of coniferous tree cover was the most important variable in explaining the variation in the number of birds detected at a sampling point (R2=0.26). Information on the distance to the nearest trail, distance to the nearest body of water and distance to the nearest extensive forest area were also important in determining the number of bird sightings. The size of the woodland (1–69 ha) played an important role in the distribution of individual bird species. About half of all species observed in these woodlands were more commonly found in the larger woods (43–69 ha). Eight species were more abundant in the smallest woodlands (1–5 ha), and a few others were apparently insensitive to the size of the woodland. Specific recommendations are made to improve the design and management of urban woodlands for enrichment of the avifauna within a city.

Tourbier, J. T. and R. N. Westmacott (1981). Water Resources Protection Technology: A handbook of measures to protect water resources in land development, Urban Land Institute.

Trettin, C. C. and M. F. Jurgensen (2003). Carbon Cycling in Wetland Forest Soils. Boca Raton, FL, CRC Press**:** 311-332.

U.S, E. P. A. (1995). Storm Water Discharges Potentially Addressed by Phase II of the National Pollution Discharge Elimination System Storm Water Program. Report to Congress, EPA Office of Water.

U.S, E. P. A. (2009). Environmental Impact and Benefits Assessment for Final Effluent Guidelines and Standards for the Construction and Development Category.

U.S.G.S (1983). Flood Characteristics of Urban Watersheds in the United States.

U.S.G.S (1994). Investigation of bridge scour at selected sites on Missouri streams**:** 40-40.

U.S.G.S and D. O. T. U.S (2002). Field Observations and Evaluations of Streambed Scour at Bridges - FHWA-RD-03-052 - Hydraulics Engineering - FHWA, Federal Highway Administration, Office of Infrastructure Research and Development.

U.S.G.S, U. S. D. O. I. (1997). Stream Stability and Scour Assessments at Bridges in Massachusetts. Marlborough, MA.

U.S.G.S, U. S. D. O. I. (1999). Assessing Biological Effects from Highway-Runoff Consituents**:** 53-53.

U.S.G.S, U. S. D. O. I. (2004). Geographic Analysis and Monitoring Program Urban Growth in American Cities, U.S.G.S.

U.S.G.S, U. S. D. O. I. (2009). Derivation of Nationally Consistent Indices Representing Urban Intensity within and across Nine Metropolitan Areas of the Conterminous United States.

Utz, R. M., R. H. Hilderbrand, et al. (2009). "Identifying regional differences in threshold responses of aquatic invertebrates to land cover gradients." Ecological Indicators **9**: 556-567.

Villarini, G., J. A. Smith, et al. (2009). "Flood frequency analysis for nonstationary annual peak records in an urban drainage basin." Advances in Water Resources **32**: 1255-1266.

Vogel, J. R., D. M. Stoeckel, et al. (2007). "Identifying Fecal Sources in a Selected Catchment Reach Using Multiple Source-Tracking Tools." J Environ Qual **36**(3): 718-729.

Given known limitations of current microbial source-tracking (MST) tools, emphasis on small, simple study areas may enhance interpretations of fecal contamination sources in streams. In this study, three MST tools--Escherichia coli repetitive element polymerase chain reaction (rep-PCR), coliphage typing, and Bacteroidales 16S rDNA host-associated markers--were evaluated in a selected reach of Plum Creek in south-central Nebraska. Water-quality samples were collected from six sites. One reach was selected for MST evaluation based on observed patterns of E. coli contamination. Despite high E. coli concentrations, coliphages were detected only once among water samples, precluding their use as a MST tool in this setting. Rep-PCR classification of E. coli isolates from both water and sediment samples supported the hypothesis that cattle and wildlife were dominant sources of fecal contamination, with minor contributions by horses and humans. Conversely, neither ruminant nor human sources were detected by Bacteroidales markers in most water samples. In bed sediment, ruminant- and human-associated Bacteroidales markers were detected throughout the interval from 0 to 0.3 m, with detections independent of E. coli concentrations in the sediment. Although results by E. coli-based and Bacteroidales-based MST methods led to similar interpretations, detection of Bacteroidales markers in sediment more commonly than in water indicates that different tools to track fecal contamination (in this case, tools based on Bacteroidales DNA and E. coli isolates) may have varying relevance to the more specific goal of tracking the sources of E. coli in watersheds. This is the first report of simultaneous, toolbox approach application of a library-based and marker-based MST analyses to flowing surface water.

Walsh, C. J., T. D. Fletcher, et al. (2009). "Retention Capacity: A Metric to Link Stream Ecology and Storm-Water Management." Journal of Hydrologic Engineering **14**: 399-406.

Walters, D. M., A. H. Roy, et al. (2009). "Environmental indicators of macroinvertebrate and fish assemblage integrity in urbanizing watersheds." Ecological Indicators **9**: 1222-1233.

Wang, L. H. and P. Kanehl (2003). "Influences of watershed urbanization and instream habitat on macroinvertebrates in cold water streams." Journal of the American Water Resources Association **39**: 1181-1196.

Weiskel, P. (2010). Preliminary Assessment of Factors Influencing Riverine Fish Communities in Massachusetts, Massachusetts Sustainable Water Management Initiative Technical Advisory Committee, Personal Communication.

Wenger, S. J., J. T. Peterson, et al. (2008). "Stream fish occurrence in response to impervious cover, historic land use, and hydrogeomorphic factors." Canadian Journal of Fisheries and Aquatic Sciences **65**: 1250-1264.

White, M. D. and K. A. Greer (2006). "The effects of watershed urbanization on the stream hydrology and riparian vegetation of Los Penasquitos Creek, California." Landscape and Urban Planning **74**: 125-138.

White, W. A., R. A. Morton, et al. (2002). "A comparison of factors controlling sedimentation rates and wetland loss in fluvial-deltaic systems, Texas Gulf coast." Geomorphology **44**(1-2): 47-66.

> Submergence of coastal marshes in areas where rates of relative sea-level rise exceed rates of marsh sedimentation, or vertical accretion, is a global problem that requires detailed examination of the principal processes that establish, maintain, and degrade these biologically productive environments. Using a simple 210Pb-dating model, we measured sedimentation rates in cores from the Trinity, Lavaca-Navidad, and Nueces bayhead fluvial-deltaic systems in Texas where more than 2000 ha of wetlands have been lost since the 1950s. Long-term average rates of fluvial-deltaic aggradation decrease southwestward from 0.514±0.008 cm year-1 in the Trinity, 0.328±0.022 cm year-1 in the Lavaca-Navidad, to 0.262±0.034 cm year-1 in the Nueces. The relative magnitudes of sedimentation and wetland loss correlate with several parameters that define the differing fluvial-deltaic settings, including size of coastal drainage basin, average annual rainfall, suspended sediment load, thickness of Holocene mud in the valley fill, and rates of relative sea-level rise. There is some evidence that upstream reservoirs have reduced wetland sedimentation rates, which are now about one-half the local rates of relative sea-level rise. The extant conditions indicate that fluvial-deltaic marshes in these valleys will continue to be lost as a result of submergence and erosion.

Williams, E. S. and W. R. Wise (2006). "HYDROLOGIC IMPACTS OF ALTERNATIVE APPROACHES TO STORM WATER MANAGEMENT AND LAND DEVELOPMENT." Journal of the American Water Resources Association **42**(2): 443-455.

> Low impact development (LID) and other land development methods have been presented as alternatives to conventional storm water management and site design. Low impact development encourages land preservation and use of distributed, infiltration-based storm water management systems to minimize impacts on hydrology. Such systems can include shallow retention areas, akin to natural depression storage. Other approaches to land development may emphasize land preservation only. Herein, an analysis of four development alternatives is presented. The first was Traditional development with conventional pipe/pond storm water management and half-acre lots. The second alternative was Cluster development, in which implementation of the local cluster development ordinance was assumed, resulting in quarter-acre lots with a pipe/pond storm water management system and open space preservation. The "Partial" LID option used

the same lot layout as the Traditional option, with a storm water management system emphasizing shallow depression storage. The "Full" LID used the Cluster site plan and the depression storage-based storm water management system. The alternatives were compared to the hydrologic response of existing site conditions. The analysis used two design storms and a continuous rainfall record. The combination of land preservation and infiltration-based storm water management yielded the hydrologic response closest to existing conditions, although ponds were required to control peak flows for the design storms. [ABSTRACT FROM AUTHOR]

Wolman, M. G. (1967). "A Cycle of Sedimentation and Erosion in Urban River Channels."

Historical evidence and contemporary measurements indicate in the Piedmont of Maryland that successive changes in land use have been accompanied by changes in sediment yield and in the behavior of river channels. Sediment yields from forested areas in the pre-farming era appear to have been less than 100 tons/sq.mi/year. Yields from agricultural lands in the same region at a later time range from 300 to 800 t/sq. mi./year. Small channel systems become clogged with sand during this construction period. While sediment deposited in channels during construction is gradually removed by subsequent clearer flows, rates of removal are slow and hampered by deposition of debris. Increased runoff from urban areas coupled with a deline in sediment yeilds to values on the order of 50 to 100 t/sq. mi. promote continued bank erosion and channel widening. Maximum observed rates of bank erosion were on the order of 1.0 foot per year. Raw banks adjacent to coarse cobble bars are widespread deposits of flotsam and debris attest to the flood regimen of urban rivers. Canalization in concrete does not eliminate such debis nor does it eliminate deposition of sediment as local changes in gradient, excessive channel width, and debris accumulation foster deposition even in canalized reaches.

Wu, C. J., L. L. S. Lin, et al. (2008). "Nonpoint Source Pollution." Water Environment Research **80**: 1827-1843.

Wu, J. S., C. J. Allan, et al. (1998). "Characterization and pollutant loading estimation for highway runoff." Journal of Environmental Engineering-Asce **124**: 584-592.

Yan, T. and M. Sadowsky (2007). "Determining Sources of Fecal Bacteria in Waterways." Environmental Monitoring and Assessment **129**(1): 97-106.

Abstract The microbiological contamination of waterways by pathogenic microbes has been, and is still, a persistent public safety concern in the United States and in most countries of the world. As most enteric pathogens are transmitted through the fecal–oral route, fecal pollution is generally regarded as the major contributor of pathogens to waterways. Fecal pollution of waterways can originate from wastewater treatment facilities, septic tanks, domestic- and wild-animal feces, and pets. Because enteric pathogens are derived from human

or animal sources, techniques capable of identifying and apportioning fecal sources have been intensively investigated for use in remediation efforts and to satisfy regulatory concerns. Pollution of human origin is of the most concern, since human feces is more likely to contain human-specific enteric pathogens. Fecal indicator bacteria have been used successfully as the primary tool for microbiologically based risk assessment. However measurement of fecal indicator bacteria does not define what pathogens are present, or define the sources of these bacteria. Microbial source tracking (MST) methods that have the ability to differentiate among sources of fecal pollution are currently under development. These methods will ultimately be useful for risk assessment purposes and to aid regulatory agencies in developing strategies to remediate microbiologically impaired waterways.

Zhu, W.-X., N. D. Dillard, et al. (2004). "Urban Nitrogen Biogeochemistry: Status and Processes in Green Retention Basins." Biogeochemistry **71**(2): 177-196.

Nitrogen (N) cycling has been poorly characterized in urban ecosystems. Processes involving N are of specific concern due to increasing anthropogenic inputs from fertilizer uses and fossil fuel combustion in cities. Here we report on a study of N biogeochemistry in city green retention basins and city parks in the Phoenix metropolitan area, Arizona, USA. City retention basins receive N inputs from street runoff, and along with city parks, fertilizer input from management, making these urban patches potential hot spots for biogeochemical cycling. We sampled soils from six retention basins and two non-retention city parks and measured soil organic matter (SOM) content, net N mineralization, net nitrification, denitrification potential, and intact core denitrification flux and nitrate retention. Our results showed significantly higher SOM, extractable nitrate, nitrification rates and potential denitrification rates in surface soils (0- 7.5 cm; soil that is directly affected by fertilizer N input, irrigation, and storm runoff) than in deeper soils. We also observed a distinct horizontal trend of decreasing SOM and denitrification potentials from inlet to outlet (dry well) in the retention basins. Denitrification rates, measured both as potential rates with substrate amendment ($390-1151 ng N_{2}O-Ng^{-1} soil h^{-1}$), and as intact core fluxes (3.3-57.6 mg Nm^{-2} d-1), were comparable to the highest rates reported in literature for other ecosystems. Management practices that affect biogeochemical processes in urban retention basins thus could affect the whole-city N cycling.

. "British Library Direct: Order Details." from http://direct.bl.uk/bld/PlaceOrder.do?UIN=213613790&ETOC=RN&from=searchengine.

. "Microbial Source Tracking Guide Document. EPA/600/R-05/064 | Risk Management Research | US EPA." from http://www.epa.gov/nrmrl/pubs/600r05064/600r05064.htm.

. "NASA ADS: Stream Health After Urbanization." from http://adsabs.harvard.edu/abs/2000JAWRA..36.1149F.

. "Stream health after urbanization." from http://cat.inist.fr/?aModele=afficheN&cpsidt=1520639.

. "U.S. Geological Survey, SIR 2006-5298, Use of Spatial Sampling and Microbial Source-Tracking Tools for Understanding Fecal Contamination at Two Lake Erie Beaches." from http://pubs.usgs.gov/sir/2006/5298/.